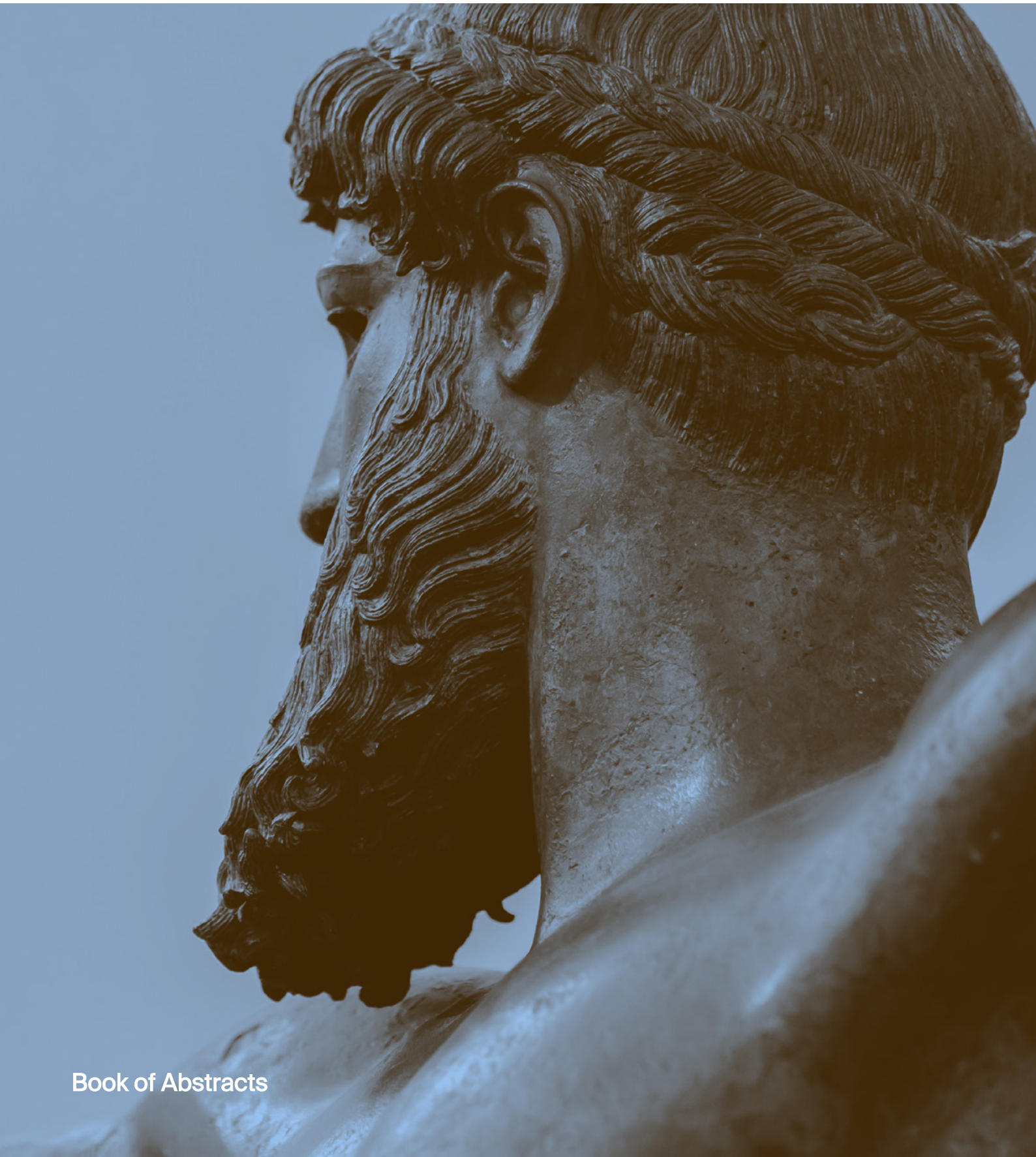
Coatings
2026
Conference

Coatings 2026: Safe and Sustainable by Design Surface Treatment and Coatings

20–22 April 2026 | Athens, Greece



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Coatings 2026: Safe and Sustainable by Design Surface Treatment and Coatings

Zeus - Wyndham Grand Athens
Athens, Greece
20–22 April 2026

Conference Chairs

Prof. Dr. Luca Magagnin
Prof. Dr. Eugenia Valsami-Jones
Dr. Alexandros Zoikis Karathanasis

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Welcome from the Chairs

Dear colleagues and friends,

We are pleased to welcome you to ***Coatings 2026: Safe and Sustainable by Design Surface Treatment and Coatings***, which will take place in Athens, Greece, from 20–22 April 2026. This conference aims to bring together researchers, industry professionals, and experts from around the world to share the latest advancements, exchange ideas, and foster collaborations in the field of Surface Finishing.

The surface finishing industry faces growing challenges, including stricter environmental regulations such as REACH and the EU Green Deal, increasing demands for pollution control, and the need to adopt cleaner, more sustainable technologies. Balancing high performance with reduced environmental impact calls for a transition toward circular economy practices, smarter formulation and production tools, and the use of less toxic, bio-based materials. By joining forces across research, policy, and supply chains, we can create coatings that meet tomorrow's standards while protecting our planet. **Your presence and active contribution will be essential in shaping a more sustainable future for surface treatment.**

Through keynote lectures, oral presentations, and poster sessions, our program is designed to offer an engaging platform for discussing cutting-edge research, emerging challenges, and future directions in the field.

We warmly encourage you to participate actively by presenting your work, joining discussions, and networking with fellow attendees. Beyond the scientific sessions, Athens offers a historic and vibrant setting to connect with colleagues while enjoying its rich culture and renowned cuisine.

We look forward to an inspiring and productive conference, and to welcoming you to ***Coatings 2026***.

Prof. Dr. Luca Magagnin
Politecnico di Milano, Italy

Prof. Dr. Eugenia Valsami-Jones
University of Birmingham, UK

Dr. Alexandros Zoikis Karathanasis
Creative Nano, Greece

Keynote Speakers

Prof. Dr. Nick Birbilis
Deakin University, Australia

Prof. Dr. Eugenia Valsami-Jones
University of Birmingham, UK

Invited Speakers

Prof. Dr. Dimitrios Bikiaris
Aristotle University of Thessaloniki, Greece

Dr. Dirk Drees
Falex Tribology N.V., Belgium

Dr. Magda Blosi
CNR-ISSMC, Italy

Dr. Emerson Coy
Adam Mickiewicz University, Poland

Prof. Dr. Andreas G. Boudouvis
National Technical University of Athens, Greece

Prof. Dr. Sergi Dosta
University of Barcelona, Spain

Prof. Dr. Maria Pia Pedeferri
Politecnico di Milano, Italy

Program

Monday, 20 April 2026
12:30 – 13:30 Registration
13:30 – 17:45

Tuesday, 21 April 2026
9:00 – 17:30 (Conference Dinner: 20:00)

Wednesday, 22 April 2026
9:00 – 18:30

	Monday, 20 April 13:30 – 17:45	Tuesday, 21 April 9:00 – 17:30	Wednesday, 22 April 9:00 – 18:30
		Keynote talk: Prof. Dr. Nick Birbilis	**Keynote talk: Prof. Dr. Eugenia Valsami-Jones**
Morning		**S1. Advances in metallic and metal matrix composite coatings**	**S10. Phasing out substances of concern from the surface finishing industry**
		Coffee Break & Poster Session A	**Coffee Break & Poster Session B**
		S5. Application of the SSbD framework on the surface finishing industry	**S9. AI tools and simulations (Part 1)**
	Opening Ceremony (Check-in from 12:30 with beverages)	**Lunch Break & Poster Session A** **Group Photo**	**Lunch Break & Poster Session B**
Afternoon	**S7. Thin film technologies and applications (Part 1)**	**S2. Advances in organic and hybrid coatings (Part 1)**	**S9. AI tools and simulations (Part 2)** -- **S8. Anodizing of light alloys**
	Coffee Break	**Coffee Break & Poster Session A**	**Coffee Break & Poster Session B**
	S7. Thin film technologies and applications (Part 2) -- **S3. Advances in methods and equipment** -- **S4. Surface finishing for additive manufacturing**	**S2. Advances in organic and hybrid coatings (Part 2)** **S2. Advances in organic and hybrid coatings (Part 3)**	**S6. Advances in thermal spraying** **Closing & Award Ceremony**
	Welcome reception with drinks	**Conference Dinner** (20:00)	

Day 1 – Monday, 20 April 2026

from 12:30	**Check-In**	
13:30-13:45	**Opening Ceremony**	
S7. Thin film technologies and applications (Part 1) **Chaired by Dr. Swarna Jaiswal**		
13:45-14:15	**Emerson Coy** **Invited Speaker**	Harnessing the Air-Water Interface: A Scalable Platform for Bio-inspired Polydopamine Thin Films in Multiple Applications
14:15-14:30	Aliona Nicolenco	Electrodeposited low-Pt core–shell nanoparticles as oxygen reduction electrocatalysts for PEMFCs
14:30-14:45	Georgios Skordaris	Annealing of Diamond-Coated Tools: A Flexible Approach to Enhancing Interfacial Fatigue Strength and Milling Performance
14:45-15:00	Luana de S. C. Carnaval	Functional thin films from ultrasound-modified waste-derived pectin for coating applications

15:00-15:15	Alexandros Felix Tiniakos	Using Layer-by-Layer (LbL) deposition to prepare modified GCE with functionalized and/or pristine Ti3C2Tx MXene-Graphene Oxide hybrids and their electrochemical evaluation
15:15-15:45	**Coffee Break**	

S7. Thin film technologies and applications (Part 2)

Chaired by Dr. Swarna Jaiswal

15:45-16:00	Denis Romagnoli	Modification of Diamond Like Carbon (DLC) to improve specific tribological characteristics for automotive steel components
16:00-16:15	Nafsika Angeliki Zafeiri	Performance evaluation of self-cleaning antireflective coating for photovoltaic panels

S3. Advances in methods and equipment

Chaired by Prof. Dr. Luca Magagnin

16:15-16:45	**Dirk Drees** **Invited Speaker**	From Specification to Mechanism: Lessons from Coating Tribology

16:45-17:00	Alvise Bianchin	High-Energy Ball Milling for the Synthesis and Liquid Predispersion of Nanoparticles
17:00-17:15	Giulia Gigante	Unveiling Microstructure–Property Relationships for the Design of Sustainable HEA and Cermet Coatings through High-Resolution Nanomechanical 3D High-Speed Mapping

S4. Surface finishing for additive manufacturing

Chaired by Prof. Dr. Luca Magagnin

17:15-17:30	Roberto Bernasconi	Composite Resins with Self-Activating Properties for Direct Electroless Metallization of 3D-Printed Components
17:30-17:45	Anthony Bouzakis	Micro-forging as a means for improving interlayer and surface mechanical properties in additive manufacturing
	Welcome reception with drinks	

Day 2 – Tuesday, 21 April 2026

09:00-09:45	**Nicholas Birbilis** **Keynote Speaker**	Protective coatings for steel: Current state and future prospects

S1. Advances in metallic and metal matrix composite coatings

Chaired by Dr. Alexandros Zoikis Karathanasis

09:45-10:00	Emilia Di Micco	Nanostructured Silver Coatings for Optical Fiber Sensors: Deposition and Morphological Characterization
10:00-10:15	Filippo Zoia	Effect of MoS_2 Nanoparticle Co-Deposition on Nickel Composite Coatings from Succinic Acid Electrolytes
10:15-10:30	Song Lu	Design high-entropy alloys as alternative binders
10:30-10:45	Athanasios Tzanis	Electrodeposition of nanocomposite Ni/NCDs coatings with enhanced mechanical properties
10:45-11:00	Nikolaos Theodoropoulos	Impact of ionomer optimization on performance of HT-PEM Fuel Cells at ultra-low Pt loadings

11:00-11:30	**Coffee Break and Poster Session A**	

S5. Application of the SSbD framework on the surface finishing industry

Chaired by Prof. Dr. George Katalagarianakis

11:30-12:00	**Magda Blosi** **Invited Speaker**	Bridging Safety, Functionality, and Sustainability in Surface Engineering: Lessons from ASINA and SUNSHINE EU Projects
12:00-12:15	Athanasios Giannakopoulos	Sustainability assessment and economic evaluation of novel coating solutions for replacing hard chromium coatings
12:15-12:30	Konstantina-Roxani Chatzipanagiotou	Phasing out Critical Metals in Membrane Fuel Cells: Evaluating the environmental impact and risk of Pt substitution towards optimized cathode performance
12:30-12:45	Adamantia Kostapanou	SSbD Assessment for High-Entropy Alloy Coatings
12:45-13:00	Eleonora Marta Longhin	Developing a Tiered Safety Assessment Strategy for Safe and Sustainable by Design Applications

13:00-14:30	**Lunch Break & Poster Session A** **Group Photo**	
14:30-14:45	**Presentations from Elval Colour and GEP**	
S2. Advances in organic and hybrid coatings (Part 1) **Chaired by Dr. Swarna Jaiswal**		
14:45-15:15	**Dimitrios Bikiaris** **Invited Speaker**	Bio-Based Polymers as Safe and Sustainable by Design Alternatives for Advanced Coating Application
15:15-15:30	Fabiola Brusciotti	PFAS-free sol-gel hybrid coatings for sustainable cookware, glass and food-packaging equipment
15:30-15:45	Raquel Rodriguez	Design of waterborne water and oil coatings for textile and packaging sectors

15:45-16:00	Andrea Rosati	The EnWaRec project: development of antiscaling and anticorrosion coatings for steel mill cooling water circuit
16:00-16:30	**Coffee Break & Poster Session A**	

S2. Advances in organic and hybrid coatings (Part 2)

Chaired by Dr. Swarna Jaiswal

16:30-16:45	Woraphan Intaphan	CO_2-Induced Amine Blushing and Heterogeneity in DGEBA/m-XDA Epoxy Coatings: FTIR and EIS Insights
16:45-17:00	Manasa Hegde	Nanoparticle-enhanced sol-gel coatings for erosion and fouling resistance in offshore wind turbine applications: A comparative study of metallic and carbon reinforcements
17:00-17:15	Aleksander Kucharek	Coumaric acid coatings as a method of protecting Cu and brass against corrosion in NaCl
17:15-17:30	Gelareh Momen	Toward Sustainable Ice Protection: Photothermal and Icephobic Polyurethane Nanocomposite Coatings

at 20:00	**Conference Dinner** - **The restaurant is located** at the top of **the Royal Olympic Hotel** (Address: Athanasiou Diakou 28, Athina 117 43, Grecia).

Day 3 – Wednesday, 22 April 2026

09:00-09:45	**Eugenia Valsami-Jones** **Keynote Speaker**	Making nano-enabled coatings safe and sustainable by design: opportunities and challenges

S10. Phasing out substances of concern from the surface finishing industry

Chaired by Prof. Dr. Eugenia Valsami-Jones

9:45-10:00	Mireille Rita Edith Poelman	Development of Safe and Sustainable PFAS-Free Coatings: The BIO-SUSHY Approach
10:00-10:15	Michalis Kartsinis	Cr6+- and Pd-Free Metallization of Plastics
10:15-10:30	Giovanni Bolelli	The CoBRAIN project – an overview
10:30-10:45	Luca Magagnin	Self-Activating Sprayable Resins for Sustainable Plating on Plastics

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10:45-11:00	Alexandros Zoikis Karathanasis	Eco-Conscious Ni-Based Nanocomposites as Hard Chromium Alternatives: Chemistry, Equipment Upgrades, SSbD Process Engineering, and Innovation Assessment
11:00-11:30	**Coffee Break and Poster Session B**	

S9. AI tools and simulations (Part 1)

Chaired by Prof. Dr. Andreas G. Boudouvis

11:30-12:00	**Andreas Boudouvis** **Invited Speaker**	Multiscale and data-driven analysis of chemical vapor deposition processes
12:00-12:15	Negin Madelat	Strategies for Improved Metal Coating Penetration in Porous Structures Using MITRe Modeling
12:15-12:30	Guillaume Brunin	Atomic modelling using density-functional theory and machine-learned interatomic potentials, and process optimization through active learning
12:30-12:45	Kostas Pyrgakis	POPEYE - Plating On Plastics Equation-based sYstems Engineering: Unit operations and properties prediction models for emerging plating on plastics technologies
12:45-13:00	Justas Listauskas	Simulation-Based Evaluation of Wear-Resistant Hardfacing Seams on Tillage Coulter Points
13:00-13:15	Samira Nazari	Mitigation of Wind Turbine Losses Using Simulation-Based Investigation of Micro-Engineered Antifouling and Anti-contamination Surface Technologies

13:15-14:30	**Lunch Break & Poster Session B**	
S9. AI tools and simulations (Part 2) **Chaired by Prof. Dr. Andreas G. Boudouvis**		
14:30-14:45	Jerome Muller	Multiscale simulation of PVD coating on complex objects in motion—From gas phase modelling to atomic-scale film growth
14:45-15:00	Francisco Daniel García Romero	A Multiscale Modelling Framework for Adhesion, Etching and Ni Deposition in Cr(VI)-Free Metallization of Polymers
15:00-15:15	Paulo Vieira	Integrating Simulation and Electrochemical Insights for Nickel-Based MMC Coatings
15:15-15:30	Johannes Peter Seif	Digital Innovation for PFAS-free Coating Development: The PROPLANET Replication Tool
S8. Anodizing of light alloys **Chaired by Dr. Alexandros Zoikis Karathanasis**		
15:30-16:00	**Maria Pia Pedeferri** **Invited Speaker**	Engineering Functional Surfaces through Anodic Oxidation
16:00-16:15	Lutfi Bilal Tasyürek	TiO2 nanotubes produced by two-step anodization on hydrogen detection and electrical characterization

16:15-16:45	**Coffee Break & Poster Session B**	

S6. Advances in thermal spraying

Chaired by Dr. Alexandros Zoikis Karathanasis

16:45-17:15	**Sergi Dosta** **Invited Speaker**	Deposition of High Entropy Alloys and reinforced coatings by Cold Spray
17:15-17:30	Sima Alidokht	Deformation Mechanisms in Cold-Sprayed Cantor Alloy Coatings: Microstructural Characterization and Computational Analysis
17:30-17:45	Grzegorz Kubicki	MAX phase ceramic coatings fabricated by aerosol cold spray
17:45-18:00	Lorenzo Miconi	High-temperature sliding wear performance of HVOF-sprayed TiC-HEA coatings
18:00-18:15	Alvise Bianchin	Flexible Manufacturing Approach of High-Entropy and Compositionally Complex CerMet Feedstock for Thermal Spray Applications
18:15-18:30	**Awards & Closing Ceremony**	

Poster Session A

Tuesday, 21 April 2026 (11:00–11:30, 13:00–14:15, 16:00–16:30 EEST)

Session	Number	Author	Title
A	1	Dimitrios Bikiaris	Tyrosine-Modified Surface-coated Lignin as a Bio-Based Filler in HDPE Matrix
A	2	Sofia Paraskevi Makri	Phosphorus- and nitrogen-modified lignin additives for multifunctional polymer coatings
A	3	Tsvetanka Babeva	Deposition temperature effect on properties of electrosprayed ZnO thin films
A	4	Gabriela Ryczek	Formation and Oxidation Studies of Thermal Barrier Coatings with Polymer-Derived Ceramic Bond Coats on TiAl Alloys
A	5	Rafail O. Ioannidis	Sustainable bioplastics as durable cast film substrates for printed electronics, digital printing, and biosensor applications
A	6	Katerina Lazarova	Design of Hygro-Swelling Polymer Films Exhibiting Thickness-Based Color Shifts
A	7	Guillaume Votte	Impact of Deposit Homogeneity on Sunscreen Efficacy: A Novel Quantitative Method Using LC-OCT
A	8	Kata Berkesi	Electrochemical Deposition of Ni/$Ti_3C_2T_x$ MXene Nanocomposite Coatings from a Boric Acid–Free Electrolyte
A	9	Gabriel Taillandier	Nanoscale droplet simulations: A computational framework to quantify wetting
A	10	Athanasios Tzanis	One-step electrodeposition of superhydrophobic Ni/MoS2 nanocomposite coatings
A	11	Krystian Prusik	Microstructural Evolution of Magnetic Ni-Mn-Co-In Alloy Powders for Coatings and/or Additive Manufacturing
A	12	Michele Ponzelli	PFAS-Free Coatings: Capturing a €1.8 Billion Market Opportunity
A	13	Antonio Borrego Ortega	Multiobjective optimization framework for the sustainable-by-design assessment of industrial coating production processes
A	14	Juliana P. S. Sousa	Sustainable Fluorine-Free Hydrophobic Solutions to Prevent Paint Overspray Adhesion
A	15	Esther Bermejo	The Role of Standardization in Research and Innovation Projects: Case study of Ni-based materials testing for energy applications
A	16	Ângela Lima	Enhanced Visible-Light Photocatalysis Using TiO_2/C_3N_4 Composites for Indoor Air Quality Improvement

A	17	Maite Redín Azcona	Effect of Mo, W, and Cr over the mechanical properties of clean and sustainable magnetron-sputtered AlTiN layers
A	18	Ioanna Katsavou	Assessing Market Readiness and Business Models for PFAS-Free SSbD Coating Solutions
A	19	Carla F. Martins	PFAs-free surface finishing in the automotive sector: A comprehensive mapping of approaches for safety, sustainability, and functionality
A	20	Maria A. Patras	From Strain to Solution: The Integrated Natural Product Discovery Platform at Fraunhofer IME
A	21	Guillaume Brunin	Machine learning–driven optimization of oxygen reduction reaction performance in electrodeposited Ni–W nanoparticles
A	22	Kyriazis C. Rekos	Effect of biochar functionalization on the properties of poly(butylene succinate) for sustainable coating applications
A	23	Dimitrios Bikiaris	Surface-Engineered PLA-Based Nanoparticles via Folic Acid–Functionalized Chitosan Coatings: Performance Evaluation and Targeted Drug Delivery Potential
A	24	Francisco Ferreira	Migration and Safety Assessment of Bio-Coating for Frozen Fish Packaging
A	25	Ioanna Deligkiozi	Decision support tool for selection of SSbD metallic coating alternatives

Poster Session B

Wednesday, 22 April 2026 (11:00–11:30, 13:15–14:30, 16:15–16:45 EEST)

Session	Number	Author	Title
B	1	Panagiota Eleni	Life Cycle Assessment and Costing of Metal Plating Processes on Resin-Based 3D-Printed Components
B	2	Reza Jafari	Multilayer Functional Coatings Incorporating Phase Change Materials and Aqueous Self-Lubricating Layers for Improved Anti-Icing Performance
B	3	Ioanna Deligkiozi	Financial Evaluation of Advanced Gear Coatings
B	4	Alvise Bianchin	Data collection and organization to support decision making process in material selection
B	5	Nikolaos Mekras	Machine learning for metallic coatings modeling & quality prediction
B	6	Fabian Cezar Lupu	Using thermal deposition for ballistic protection plates of bulletproof vests
B	7	Eleonora Marta Longhin	Tiered Hazard Assessment Implementing New Approach Methodologies for PFAS-Free Coatings in a Safe and Sustainable by Design Context
B	8	Pegah Zahedifar	Hydrophobic and Bio-Designed Waterborne Polyurethane Formulations for Eco-Friendly Textile Finishes
B	9	Giovanni Bolelli	Role of substrate hardness on the adhesion of DLC-based coatings deposited on L-PBF Al-Si-Mg alloys
B	10	Adam Kowalik	Light-induced thermal drying process of sol-gel layers obtained by ultrasonic atomization
B	11	Natalia Kaczmarczyk	Sol-Gel Oxide Barrier Coatings on PET Substrates for High-Pressure Hydrogen Storage Applications
B	12	Konstantina-Roxani Chatzipanagiotou	Decision Support System for Safe & Sustainable Innovation in NICKEFFECT
B	13	Aliona Nicolenco	Three-Dimensional Current Density Distribution Simulations and Experimental Determination of Electrodeposited Porous Nickel-Tungsten on Fiber Cloths Substrate
B	14	Luca Magagnin	REACH-Compliant Nickel-Based Metal Matrix Composites for Tribological Applications: A Sustainable Alternative to Hard Chromium from the MOZART Project
B	15	Srikanth Guntoju	Cardanol-Based Sustainability as an Alternative for Petroleum-Based Corrosion-Protective Coatings for Al 6061

B	16	Luana de S. C. Carnaval	Environmental pH Effects on the Stability of Sustainable Pickering Emulsions for Edible Coating Applications
B	17	Vassilios Constantoudis	Theoretical and ML-based method for thickness estimation of coatings on rough substrates using nondestructive SEM imaging
B	18	Paschalis Spinthakis	Ni-Based Coatings as Sustainable Alternatives to Hard Chromium for Aeronautical Applications
B	19	Diego Pascual Fernández	Tailoring the SSbD approach to surface treatment processes: a streamlined framework for sustainability and safety
B	20	Michalis Kartsinis	Enzyme-assisted pretreatment of PA12 for sustainable plating on plastics: Replacement of Cr^{6+} etching and Pd activation
B	21	Despoina Georgopoulou	Fabrication of fluorine-free superhydrophobic coatings via sol-gel method and spray deposition
B	22	Mirica Karlovits	The impact of measurement geometry on colorimetric properties of coatings based on cellulose nanocrystals (CNCs) and pearl luster pigments
B	23	Maria Pia Pedeferri	Recycling of dispersion-coated paper-based packaging: tracking methodology to discover and quantify microplastics
B	24	Zoi-Lina Koutsogianni	Development of Sustainable Sugar-Derived Thermosetting Resins for Eco-Friendly Plating on Plastics (PoP) Applications

High-temperature sliding wear performance of HVOF-sprayed TiC-HEA coatings

sciforum-168346

online as oral presentation (without DOI)

Lorenzo Miconi[1], Giovanni Bolelli[1], Stefania Morelli[1], Maria Francesca Bonilauri[1], Luca Bortolotti[1], Luca Lusvarghi[1], Alvise Bianchin[2], Enrico Forlin[2]

[1] University of Modena and Reggio Emilia

[2] MBN Nanomaterialia srl

Hardmetal coatings for high-temperature applications are usually based on Cr_3C_2-NiCr; however, the limited hardness and wear resistance of these systems are a drawback which is sometimes overcome through the addition of controlled amount of WC. However, W is a critical raw material subjected to significant supply insecurity and price volatility. Hence, in order to find potential alternatives, we aim to investigate TiC-based hardmetals with High-Entropy Alloy (HEA) matrices, since HEAs can maintain good mechanical strength and oxidation resistance up to elevated temperatures, and can be formulated without critical elements like W and/or Co.

In this work, we therefore studied the ball-on-disc sliding wear resistance of HVOF-sprayed coatings with 60 vol.% TiC and four different HEA coatings based on the AlCrFeNi alloys added with Cu and/or Mo, since these elements can specifically provide favorable tribo-oxidation behavior. The compositions were chosen to have a mainly FCC matrix, since HEAs with FCC lattices are typically tougher than those with BCC or hexagonal structure, which is desirable in the matrix of a hardmetal.

Especially the formulations containing simultaneously Mo and Cu exhibit stably low specific wear rates of 10^{-6} $mm^3/(N \cdot m)$ from room temperature to 800 °C under high contact pressure conditions, one order of magnitude lower than for a Cr_3C_2–25 wt%NiCr benchmark. SEM, XRD and micro-Raman analyses of the worn samples indicated that this performance was related to a tribo-oxidation mechanism based on the formation of a uniform film of molybdates. Accordingly, increasingly more continuous coverage by the oxide tribofilm resulted in a drop of the friction coefficient from 0.8 at room temperature to 0.3 at 800 °C. The results demonstrate that TiC-AlCrCuFeMoNi coatings are promising candidates for industrial applications requiring stable wear performance over a wide temperature range.

Design high-entropy alloys as alternative binders

sciforum-166982

online as oral presentation (without DOI)

Song Lu, Tomi Suhonen, Anssi Laukkanen

[1] VTT Technical Research Centre of Finland

Traditional hard metals usually use Co metal as the binder for metal carbides (WC, TiC, VC, etc.), achieving balanced combinations of properties like hardness, toughness, ductility, wear resistance. Co/WC composite has been extensively studied and widely applied in cutting tools, mining and construction, metal forming, wear parts, etc. The primary reasons for choosing Co as the binder material are related to its excellent wetting and sintering properties, a prior combination of toughness, ductility, friction and wear resistance, high thermal stability and so on. However, driven by considerations including health and environmental concerns (e.g., Cobalt is classified as a probable human carcinogen by regulatory agencies such as the International Agency for Research on Cancer (IARC)), cost, supply chain stability, and deficient corrosion resistance in certain environments, academies and industries are exploring various materials as potential alternative binders. High-entropy alloys (HEAs), composed of multi-principal elements, are a promising class of alloy for substituting Co as the binder phase. Designing suitable HEA compositions as the binder phase is however a challenging task. Previous studies are mostly based on the trial-and-error method, and only a small number of HEAs (usually the equiatomic HEAs) have been tested. In the current EU project CoBRAIN, we systematically characterize the key thermodynamic, physical and mechanical properties of HEAs in the large compositional space, and design the binder phase to have the similar properties of Co binder in terms of phase stability, deformation behaviors and magnetic properties, etc. Density functional theory (DFT) calculations have been adopted to study the composition and magnetic dependent phase stability and stacking fault energy, which are critical material properties affecting the transformation-induced plasticity (TRIP) and twinning-induced plasticity (TWIP) effects in the binder phase. Several potential compositions in various HEA systems are identified and further tested as binder in thermal spray coatings to verify the design concept. DFT results, together with experimental and theoretical results from the project, form also as a solid database for developing a fast machine learning method, supporting further optimization and customization of binder phases.

Effect of MoS_2 Nanoparticle Co-Deposition on Nickel Composite Coatings from Succinic Acid Electrolytes

sciforum-172125

online as oral presentation (without DOI)

Filippo Zoia, Luca Magagnin

[1] Politecnico di Milano

Metal Matrix Composites (MMCs) constitute an important class of engineered materials designed to overcome the inherent limitations of pure metals, particularly in terms of mechanical strength, wear resistance, corrosion protection, and tribological performance. By incorporating reinforcing phases like hard ceramic particles or 2D solid lubricants into a metallic matrix, MMCs can achieve enhanced functional properties that are difficult to obtain through alloying or conventional surface treatments alone.[1]

The development of such coatings, however, must comply with increasingly stringent environmental and health regulations. Within this context, the European project MOZART aims to deliver REACH-compliant alternatives to hard-chrome (HC) coatings by developing nickel-based MMCs capable of matching HC performance.[2] Because boric acid, a common buffering agent in commercial nickel baths, has been classified as a substance of very high concern (SVHC) due to its reproductive toxicity, safer substitutes are required. Literature reports that di- and tri-carboxylic acids such as citric acid are effective buffering agents within the operative pH range of nickel baths (pH 3–5).[3]

In this work, succinic acid is proposed as a sustainable buffering agent for the electrodeposition of nickel-based MMCs reinforced with molybdenum disulphide (MoS_2) nanoparticles. Successful co-deposition requires stable nanoparticle dispersions in the electrolyte; therefore, several surfactants were evaluated to mitigate MoS_2 agglomeration and promote uniform incorporation into the deposit.[4] The influence of each surfactant on bath stability, deposition efficiency, and the resulting co-deposition behaviour was investigated to assess whether MoS_2 incorporation effectively provides solid lubrication, reduces the coefficient of friction, and enhances the wear resistance of the resulting composite coatings.

[1] Wasekar NP, Lavakumar B. Strengthening mechanisms and tribological aspects of ceramic particle reinforced electrodeposited metal matrix composites – A review. J Alloys Compd 2025;1037:182288. https://doi.org/10.1016/j.jallcom.2025.182288.

[2] European Union, Mozart project [Online]. Accessed on 10th December, 2025. Available at https://www.mozart-project.eu/# n.d.

[3] Bigos A, Wolowicz M, Janusz-Skuza M, Starowicz Z, Szczerba MJ, Bogucki R, Beltowska-Lehman E. Citrate-based baths for electrodeposition of nanocrystalline nickel coatings with enhanced hardness. J Alloys Compd 2021;850:156857. https://doi.org/10.1016/j.jallcom.2020.156857.

[4] Liu C, Zhen H, Huang Q, Chen W, Mai Y, Zhang L, Jie X. Improvement in Tribological and Anticorrosion Performances of Co-MoS2 Composite Coatings. J Mater Eng Perform 2023;32:2237–48. https://doi.org/10.1007/s11665-022-07260-y.

Electrochemical Deposition of Ni/$Ti_3C_2T_x$ MXene Nanocomposite Coatings from a Boric Acid–Free Electrolyte

sciforum-166019

online as poster presentation (without DOI)

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Composite electrochemical coatings (CECs) based on nickel and dispersed functional particles offer an effective route to enhance the mechanical, chemical, and tribological performance of metallic surfaces. In this work, the electrochemical co-deposition of nickel with $Ti_3C_2T_x$ MXene was investigated to develop advanced Ni/MXene nanocomposite coatings with improved functional properties.

The dispersion stability of $Ti_3C_2T_x$ MXene was systematically evaluated through the screening of multiple surfactants, first in aqueous media and subsequently in the nickel electrolyte. A sustainable nickel electroplating electrolyte was utilized by substituting boric acid with tartaric acid. Dynamic Light Scattering (DLS) measurements were used to determine hydrodynamic diameter (HDD) and ζ-potential, enabling identification of the optimal dispersant for stable MXene suspensions.

Using the stable electrolyte, Ni/$Ti_3C_2T_x$ composite coatings were produced via direct-current (DC) electrochemical co-deposition at current densities of 1, 2, and 5 $A \cdot dm^{-2}$. The resulting coatings were comprehensively characterized: surface morphology and MXene distribution were examined by SEM–EDS, while phase composition and elemental content were assessed using PXRD and portable XRF. Mechanical and surface properties were evaluated through Vickers microhardness testing and water contact angle measurements, providing insight into the structure–property relationships governing the performance of the developed nanocomposite coatings.

Electrodeposition of nanocomposite Ni/NCDs coatings with enhanced mechanical properties

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Composite nickel coatings obtained via the electrodeposition technique play a major role in various engineering fields ranging from automotive to aerospace. Ongoing research is focusing on enhancing its mechanical properties by embedding in the nickel matrix various strengthening particles in either the nano or the micro scale [1,2]. Nitrogen-doped carbon dots (NCDs) belong to the novel and rapidly advancing subcategory scientific area of carbonaceous nanomaterials, which exhibit improved properties, while they can be produced by green chemistry methods and can be exploited in various fields such as energy, environment or catalysis [3]. Interestingly, only few studies refer to composite nickel-matrix/NCDs and the resulting mechanical properties [4]. In the current study we report the successful incorporation of NCDs, fabricated by hydrothermal treatment and microwave irradiation, in a nickel-matrix coating through a one-step electrodeposition process at the direct current regime. Quantitative stoichiometric analysis of the carbon content in the coatings was achieved by means of an infrared combustion analyzer. In addition, the coatings were studied for their microstructural characteristics and surface morphologies, by means of X-ray diffraction and scanning electron microscopy, respectively. The mechanical properties of the coatings were studied by performing microhardness indentation testing. This study will also permit us to discuss a new additive-free composite nickel coating with enhanced hardness properties to be exploited for potential mechanical applications.

Impact of ionomer optimization on performance of HT-PEM Fuel Cells at ultra-low Pt loadings

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High-temperature polymer electrolyte membrane fuel cells (HT-PEMFCs) offer improved tolerance to fuel impurities, simplified water management, and enhanced reaction kinetics relative to low-temperature systems. Despite these advantages, their large-scale deployment is still limited by the high platinum loadings required at both electrodes: the anode, to sustain efficient hydrogen oxidation (HOR) under elevated temperatures, and especially the cathode, where oxygen reduction reaction (ORR) kinetics dominate performance losses and cost. Reducing Pt content at both electrodes without compromising activity or durability remains a critical challenge. This work presents a scalable approach to the fabrication of electrocatalysts based on electrodeposited core-shell nanoparticles, enabling a drastic reduction in Pt loading and achieving notable HT-PEMFC performance.

Catalyst nanoparticles were electrodeposited directly onto the microporous layer (MPL), which already contains conductive carbon-based supports, ensuring precise control over particle size, distribution, and metal content, and achieving ultra-low Pt loadings. Beyond catalyst synthesis, this study focuses on the critical role of ionomer content within the catalyst layer on membrane electrode assembly (MEA) performance. While ionomer is essential for proton transport and catalyst utilization, excessive or insufficient ionomer concentrations can severely hinder gas diffusion, electronic connectivity, and active site accessibility. Systematic optimization of ionomer concentration revealed a narrow operating window in which electrodeposited nanoparticle catalysts exhibit maximal performance. At optimized ionomer loadings, improved triple-phase boundary formation and reduced mass transport losses were observed, resulting in enhanced cell voltage and power density.

The combined strategy of electrodeposition-based catalyst fabrication and ionomer optimization demonstrates a viable pathway toward high-performance HT-PEMFCs with drastically reduced Pt loadings. These findings underscore the importance of integrated catalyst-ionomer design in MEA engineering and provide valuable insights for the development of next-generation, low-cost fuel cell technologies.

Microstructural Evolution of Magnetic Ni-Mn-Co-In Alloy Powders for Coatings and/or Additive Manufacturing

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Magnetic Ni-Mn-Co-In alloys, belonging to the family of magnetic shape memory alloys, exhibit a reversible martensitic transformation that can be triggered by temperature, stress, or magnetic fields, enabling functional strain and field-responsive behawior [1,2]. Translating these properties to coatings and/or additive manufacturing requires powder feedstocks with controlled phase stability and microstructural robustness, because the alloy system is intrinsically brittle and sensitive to processing-induced cracking. In this work, we investigate how minor alloying additions—representing a light element (B) and a heavy element (Mo)—influence the microstructural evolution and transformation behavior of Ni-Mn-Co-In powders designed for thermal spray and powder-bed processing routes. Powders with 0–4 wt.% additions were produced and subjected to tailored thermal treatments to simulate thermal histories relevant to coating deposition and layer-wise consolidation. Scanning electron microscopy and EBSD reveal a matrix–precipitate microstructure, with addition-rich particles dispersed throughout the powder and evolving in volume fraction with composition. DSC shows systematic shifts of martensitic transformation temperatures by ~50–60 K. Phase constitutions and lattice structures are resolved by XRD and TEM, providing guidance for composition–process windows suitable for functional coatings and additively manufactured components.

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Nanostructured Silver Coatings for Optical Fiber Sensors: Deposition and Morphological Characterization

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In the civil and industrial fields, precise control of process parameters is a fundamental requirement to ensure safety and reliability. Sensor technologies provide a wide range of solutions for monitoring chemical and physical quantities. Owing to their immunity to electromagnetic interference, mechanical robustness, and small dimensions, optical fiber sensors—particularly Fiber Bragg Gratings (FBGs)—enable the monitoring of parameters such as temperature and strain even under harsh environmental conditions, ranging from cryogenic temperatures to values exceeding 1000 °C. A crucial aspect of optical fiber performance is related to external coatings, which directly influence mechanical behavior, durability, and compatibility with specific applications. Commercial optical fibers are typically coated with a polymeric layer that provides mechanical protection and facilitates handling. In this work, a nanostructured silver-based metallic coating is deposited via a bottom-up chemical process involving a redox reaction between silver nitrate ($AgNO_3$) and glucose solutions; its morphological characteristics are investigated. Depositions are performed on bare optical fibers and on fibers coated with polymeric materials, including acrylate, polyimide, and Ormocer®. Through the optimization of process parameters—including pH, temperature, deposition time, and coating thickness—and the study of surface chemical compatibility, the quality of the metallic layers is evaluated for adhesion, uniformity, and homogeneity. The novelty of this work lies in the optimization of a metal deposition approach that is rarely reported for optical fiber coatings. Its application to polymer-coated fibers requires addressing substrates with tailored thermal and chemical resistance, prompting a thorough evaluation of their physicochemical properties to ensure effective metal adhesion and compatibility. Overall, this study contributes to the scientific literature by assessing the potential direct applicability of this method to FBG sensors and by providing a solid foundation for future investigations into sensor performance and the enhancement of measurement capabilities.

Ni-Based Coatings as Sustainable Alternatives to Hard Chromium for Aeronautical Applications

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Sustainability in engineering systems is strongly influenced by corrosion, as material degradation directly affects component lifetime, maintenance requirements, and recyclability. This is particularly critical for aeronautical components, where durability, reliability, and environmental performance are essential. Protective coatings are widely employed to prevent corrosion, with hard chromium (Cr) plating traditionally used in the aeronautical industry due to its excellent mechanical and wear properties. However, increasing environmental and health concerns associated with hard Cr processes have created significant pressure to develop safer and more sustainable alternatives.

In this context, Ni-based coatings have emerged as promising alternatives. Their properties can be tailored either through alloying element additions or by incorporating strengthening particles to enhance mechanical performance. Nevertheless, improvements in mechanical properties often come at the expense of electrochemical performance, as alloying additions or particle incorporation may negatively affect corrosion resistance. Thus, in this work, we investigate the effect of incorporating Sn as an alloying element or ZrO_2 particles as a reinforcing phase on the corrosion behavior of Ni-coated steel in a 3.5% NaCl solution. The objective is to establish a structure–corrosion relationship by correlating microstructural characterization with potentiodynamic polarization measurements. The results indicate that, for Ni–Sn coatings, the Sn content plays a critical role in determining corrosion performance. Similarly, for Ni–ZrO_2 composite coatings, a threshold in particle concentration governs the electrochemical response. These findings provide insight into optimizing Ni-based coatings for enhanced corrosion resistance, contributing to more sustainable surface engineering solutions for aeronautical applications.

One-step electrodeposition of superhydrophobic Ni/MoS_2 nanocomposite coatings

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Nickel electrolytic deposition is among the most commonly employed methods for numerous applications. Researchers have extensively examined the influence of various electrolysis parameters, as well as the impact of incorporating various additives or secondary reinforcing agents. Particularly composite Ni-MoS_2 coatings have attracted significant attention because of their enhanced wear resistant properties. In the present study we investigated the wetting properties of electrodeposited coatings fabricated in a Watts-type electrolyte containing MoS_2 nanoparticles at selected concentrations. The electrodeposition was conducted at various current densities by utilizing the standard three-electrode setup. The microstructure of the coatings was studied with x-ray diffractometry (XRD), while the surface morphology through scanning electron microscopy (SEM). The stoichiometric analysis was accomplished by an energy dispersive spectrometer (EDS) coupled on the SEM. Water contact angle measurements were performed by measuring the static water contact angle and the sliding angle at ambient conditions. The results showed that the successfully-prepared nanocomposite coatings exhibited superhydrophobic properties which are enhanced as the current density increases, enabling the utilization of such coatings in self-cleaning and water repellent applications.

Performance evaluation of self-cleaning antireflective coating for photovoltaic panels

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online as oral presentation (without DOI)

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Dust accumulation or stains on photovoltaic (PV) panels pose a significant challenge, reducing efficiency and shortening lifespan. Commonly used cleaning methods, such as manual cleaning, rely on water, which raises concerns about the economic and environmental feasibility of the technique. To address this challenge, a self-cleaning mechanism via a novel water/isopropyl alcohol-based coating developed by NanoPhos S.A. is investigated, which provides antireflective performance that could increase the transmittance of PV glass while reducing dust deposition. In this study, the impact of a self-cleaning, super-hydrophilic, and photocatalytic coating is investigated. The evaluation of the coated panels is demonstrated in accordance with IEC 61724-1:2021 in Greece, at the Technological and Cultural Park demonstration site in Lavrion. To evaluate the PV performance, crucial parameters, such as yields, losses, and efficiencies, are computed. The analysis is conducted within the services offered by the Open Innovation Test Beds, which enable material suppliers to integrate their innovative, carbon-neutral material solutions into the European Key Value Chain. The study's findings indicate an average gain of over 5% in the performance ratio across the entire period.

Sustainability assessment and economic evaluation of novel coating solutions for replacing hard chromium coatings

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Hard chromium (HC) has been the dominant protective coating for a wide range of applications offering high hardness (750-1050 HV), and excellent wear and corrosion resistance However, the hard chrome plating process involves the use of hexavalent chromium, (Cr(VI)), which is highly toxic, carcinogenic and mutagenic and associated with severe respiratory problems. Thus the emission and wastes of the process are dangerous for the workers and the environment. Consequently, on February 15th 2019, REACH Committee has set a stricter regulation frame for the use of Cr(VI) substances, proposing authorization and limits to the use of chromium trioxide[1]. To address this challenges, the replacement of HC coatings with novel nickel-based nanocomposite coatings is investigated. The European research project MOZART promotes the incorporation of silicon carbide and graphene nanoparticles (NPs) in the Nickel matrix leading to two novel coatings with enhanced physicochemical, mechanical and environmental properties are examined in the framework of the. In this study, a sustainability assessment of two coatings is performed, comprising Life Cycle Assessment and Life Cycle Cost analyses according to the ISO 14040-44 standards with a functional unit of 1m^2 of coated surface, with 10um coating thickness. The results demonstrate significant improvement of human carcinogenic toxicity and freshwater ecotoxicity reduction while the economic performance proving the feasibility of the new coatings.

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Unveiling Microstructure-Property Relationships for the Design of Sustainable HEA and Cermet Coatings through High-Resolution Nanomechanical 3D High Speed Mapping

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Developing next-generation high-performance coatings requires quantitative tools capable of resolving how local heterogeneities and microstructural gradients influence mechanical behaviour. In this work, we present an advanced nanoindentation-mapping methodology for producing high-resolution 3D mechanical property maps, enabling spatially resolved assessment of hardness and modulus across highly heterogeneous thermally sprayed surfaces. This approach reconstructs continuous mesoscale mechanical landscapes that capture the effects of splat boundaries, porosity, amorphous regions, and interfacial transitions, features that conventional indentation grids cannot resolve.

As a representative case study, we apply this methodology to High Entropy Alloy (HEA) and cermet coatings developed within the EU project CoBRAIN[1], which aims to create sustainable and high-performance alternatives to cobalt-containing materials for advanced manufacturing. The coatings, produced using thermal spraying techniques, exhibit pronounced microstructural and mechanical heterogeneity due to rapid solidification and the intrinsic complexity of multi-principal element systems. The resulting 3D mechanical maps reveal distinct mechanical phases, including FCC, BCC, oxides and TiC-rich regions, with hardness values and spatial distributions consistent with phase-specific statistical clustering obtained through GMM deconvolution.

Overall, the use of high-resolution nanomechanical 3D mapping provides a powerful framework for correlating microstructure and performance in thermally sprayed HEA and cermet coatings, supporting the design and optimization of next-generation CoBRAIN materials.

https://www.cobrain-project.eu/

Multilayer Functional Coatings Incorporating Phase Change Materials and Aqueous Self-Lubricating Layers for Improved Anti-Icing Performance

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Ice formation on exposed surfaces remains a critical challenge for infrastructure operating in cold environments, where conventional passive anti-icing coatings often suffer from limited effectiveness and durability. This work presents a multilayer coating strategy that integrates aqueous self-lubricating surface chemistry with an underlying phase change material (PCM)-containing layer to achieve enhanced, synergistic anti-icing performance.

The top layer consists of a PEG-PDMS copolymer-modified coating that forms a quasi-liquid-like (QLL) interfacial water layer, as directly confirmed by solid-state NMR spectroscopy. The presence of this viscous interfacial layer delays ice nucleation and significantly reduces ice adhesion by limiting molecular mobility at the ice–coating interface. Differential scanning calorimetry further demonstrated that this interfacial lubrication mechanism lowers the ice nucleation temperature through viscosity-driven kinetic effects. Encapsulated PCMs were selected to release latent heat within the critical temperature range associated with glaze ice formation. Infrared thermography demonstrated that PCM-containing samples maintained higher surface temperatures during cooling from 0 to −20 °C, effectively prolonging the lifetime of the QLL. As a result, the complete freezing time increased dramatically from approximately 190 s for PDMS to up to 1560 s for coatings containing 50 wt.% PCM.

Ice adhesion measurements showed a substantial reduction for PEG-PDMS coatings compared to PDMS references, with a further decrease observed when the PCM layer was incorporated. Static-accumulation tests conducted at −5 °C confirmed a significant reduction in ice accretion for the multilayer system compared to single-layer coatings. Importantly, positioning the PCM beneath the self-lubricating layer preserved mechanical integrity while mitigating PCM depletion, enabling higher PCM loading without compromising coating durability.

This multilayer design demonstrates how thermal energy storage and interfacial lubrication can be combined effectively to overcome the limitations of individual anti-icing strategies, offering a robust, scalable pathway for next-generation passive icephobic coatings.

Cardanol-Based Sustainable as an alternative for Petroleum-Based Corrosion-Protective Coatings for Al 6061

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online as poster presentation (without DOI)

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The development of sustainable corrosion-protective coatings from renewable feedstocks has attracted growing interest as an alternative to conventional petroleum-based systems. In our earlier work, we investigated bio-based coating platforms derived from cyclic carbonated vegetable oils, particularly cyclic carbonated soybean oil (CSBO), for the preparation of non-isocyanate polyurethane (NIPU) and hybrid networks with promising corrosion resistance on aluminium substrates. Building on these findings, the present study explores cardanol-based coatings as a complementary bio-derived approach for advanced surface protection.

Cardanol, obtained from cashew nut shell liquid, possesses a unique molecular structure comprising an aromatic ring and a long hydrophobic aliphatic side chain, making it an attractive precursor for protective coating applications. These structural features are expected to enhance coating hydrophobicity, barrier performance, and resistance to electrolyte ingress, all of which are critical for long-term corrosion mitigation. Drawing from our previous understanding of bio-based network formation, curing behavior, and coating–substrate interactions, this work examines how cardanol-based chemistry can be leveraged to achieve durable and environmentally responsible corrosion protection.

The study correlates the present cardanol system with our prior investigations on CSBO-based NIPU and hybrid coatings, with emphasis on coating formation, structural evolution, and electrochemical performance. The coatings are evaluated using FTIR, thermal analysis, surface wettability, morphology, electrochemical impedance spectroscopy, and polarization measurements to establish structure–property–performance relationships. Overall, this work highlights cardanol as a promising renewable building block for corrosion-resistant coatings and demonstrates how insights from earlier vegetable-oil-based systems can guide the design of next-generation sustainable protective materials for metallic substrates.

CO_2-Induced Amine Blushing and Heterogeneity in DGEBA/m-XDA Epoxy Coatings: FTIR and EIS Insights

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Epoxy-amine coatings are widely used for metal protection because they provide strong interfacial bonding, long service life, and excellent corrosion resistance. In this work, Bisphenol A diglycidyl ether (DGEBA) cured with m-xylylenediamine (m-XDA) was used as a model system to investigate how environmental CO_2 affects coating heterogeneity and optical appearance. Particular attention was given to amine blushing, since m-XDA can react rapidly with atmospheric CO_2 to adsorb and to form carbamated species on the coating surface, leading to reduced transparency of both the bulk polymer and the film.

DGEBA/m-XDA specimens were cured at room temperature under either N_2 or a CO_2-containing ambient atmosphere, and characterised using Fourier-transform infrared spectroscopy (FTIR) and electrochemical impedance spectroscopy (EIS). The CO_2-exposed samples showed pronounced inhomogeneity throughout the bulk, obvious surface amine blushing, and strong bands at 2400–2300 cm^{-1} attributed to CO_2 species trapped in the polymer matrix, which correlated with decreased transparency, whereas the N_2-cured samples appeared more homogeneous and showed no evidence of CO_2 capture. Subsequent high-temperature treatment at 160 °C greatly reduced the CO_2-related FTIR bands, indicating that CO_2 near the surface could desorb, although cloudiness remained in much of the bulk and only localised regions showed disappearance of carbamate/carbamic acid features with concurrent strengthening of bands near 1700 cm^{-1} and in C–N/N–H regions.

Free-standing films cured at 60 °C and post-cured at 100 and 160 °C were also evaluated by EIS, which revealed no significant differences in coating resistivity between CO_2-exposed and N_2-cured samples. These results suggest that CO_2 uptake and carbamate formation at the surface mainly influence visual appearance and micro-scale heterogeneity rather than global barrier performance. The study highlights the critical role of cure atmosphere in controlling amine blushing and optical properties of epoxy-amine coatings without severely compromising their electrochemical corrosion protection.

Coumaric acid coatings as a method of protecting Cu and brass against corrosion in NaCl

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Copper is an extremely important metal applied in electronics, transportation, or construction. Despite its great corrosion resistance, Cu can undergo pitting corrosion under certain conditions (polluted air and water). Furthermore, Cu is a component of brass - an alloy that many historic artefacts are made of. Brass similarly to Cu is relatively resistant to corrosion. However, prolonged exposure to atmospheric corrosion may result in its selective corrosion called dezincification leading to severe damages. Thus, it is crucial to develop an efficient and ecological method of protecting aforementioned materials against corrosion, with particular emphasis on historic heritage artefacts, especially due to their cultural values being lost irreversibly.

Coumaric acid (CA) is one of the derivatives of cinnamic acid and is considered to be a green corrosion inhibitor. This compound has been proved to be an efficient corrosion inhibitor for Fe and steel [1]. Our previous investigation results have also proved CA inhibitory effect on corrosion of the second brass component – Zn, similarly as in the case of caffeic acid [2]. However, no reports have been found on application of coumaric acid as a corrosion inhibitor for brass or Cu.

In this study, the impact of coumaric acid coatings on Cu and brass corrosion has been investigated with the application of electrochemical methods such as measurement of open circuit potential (OCP), potentiodynamic polarisation (PDP) and electrochemical impedance spectroscopy (EIS). Different number of CA layers were deposited from CA ethanol solutions of different concentrations. Results indicate that the best inhibition efficiency (86%) for Cu was obtained for 10 layers deposited from 10 mM CA solution, whereas the best inhibition efficiency (70%) for brass was obtained also for 10 layers but deposited from 20 mM CA solution. The EIS measurements confirmed the PDP results. Applied coatings do not change the colour and the appearance of the protected samples indicating their possible application in the case of historic heritage artefacts.

Acknowledgement: This work has been completed while the first author was the Doctoral Candidate in the Interdisciplinary Doctoral School at the Lodz University of Technology, Poland.

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Design of waterborne water and oil coatings for textile and packaging sectors

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online (without DOI)

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Per- and polyfluoroalkyl substances (PFAS) possess a unique combination of properties—such as exceptional water and oil repellency, high thermal and chemical stability, pronounced oxygen affinity, and effective surfactant behavior—that have enabled their widespread use across industrial applications and consumer products since the 1940s. However, increasing concern over their persistence and potential adverse impacts on human health and the environment has prompted regulatory action. In 2020, the European Union adopted Regulation (EU) 2020/784 to restrict the manufacture and use of persistent organic pollutants, specifically limiting concentrations of PFOA, its salts, and related compounds to a maximum of 1 mg/kg in substances that meet the PFAS definition and are incorporated into consumer products [1].

Given the high persistence of PFAS and significant knowledge gaps regarding the properties, uses, and toxicological profiles of many PFAS currently in use, there is growing consensus that their production and application should be significantly reduced. This drives the need to substitute hazardous chemicals—particularly in consumer-facing applications—with safer, more sustainable alternatives. Developing PFAS-free coatings that deliver equivalent performance while minimizing environmental impacts across their life cycle remains a major challenge.

The objective of this work is to develop novel bio-based coatings for the textile and packaging sectors that provide water and oil repellency comparable to PFAS-based formulations. The new coatings are synthesized from biomass-derived resources using an environmentally friendly polymerization process. Process parameters and their influence on final material properties were systematically evaluated, enabling the optimization of coatings tailored to textile and packaging applications.

Development of Sustainable Sugar-Derived Thermosetting Resins for Eco-Friendly Plating on Plastics (PoP) Applications

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online (without DOI)

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Driven by the need for eco-friendly alternatives to fossil-fuel-based products, there has been a growing interest regarding sustainable materials and green chemistry. This shift is particularly evident in the polymer sector, which has been transitioning away from traditional sources over the last several decades. Currently, most industrial epoxy resins rely on Bisphenol A (BPA), a petroleum-based chemical known for its reproductive toxicity. This work explores the development of sustainable thermosetting resins and their subsequent use in Plating on Plastics (PoP) technology. By utilizing sugar-derived precursors such as itaconic acid and isosorbide, epoxy and epoxy-acrylate resins were successfully synthesized. The study optimized reaction parameters and utilized characterization methods—including NMR, FTIR, and EEW titration—to confirm the chemical structure and the successful incorporation of epoxy and acrylate functional groups. Thermal and mechanical assessments (via DSC, TGA, and DMA) revealed that the performance of these bio-derived resins is comparable with standard BPA-based systems when cured under similar conditions. Furthermore, these resins were developed into composite coatings by incorporating nickel salts and applied to ABS surfaces. This approach seeks to replace hazardous traditional PoP steps, specifically eliminating the use of toxic hexavalent chromium in the etching phase and expensive palladium catalysts during activation. The successful loading of nickel salts into the bio-polymeric matrix highlights the potential of these materials for functional coatings. Ultimately, this study validates that bio-based thermosets are viable substitutes for conventional epoxies, offering a path toward more sustainable and less hazardous plastic metallization processes.

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Effect of biochar functionalization on the properties of poly(butylene succinate) for sustainable coating applications

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Poly(butylene succinate) (PBS) is a bio-based and biodegradable aliphatic polyester that has attracted increasing interest as a sustainable binder for coating applications. Despite its favorable environmental profile, the moderate mechanical strength, thermal resistance, and barrier performance of PBS can restrict its use in demanding coating systems. In this study, biochar (BC), a low-cost carbon-rich material derived from biomass, was employed as a functional filler to tailor PBS properties, with emphasis on the role of biochar functionalization and its impact on coating-relevant performance. PBS/BC composites containing low biochar loadings were prepared via melt-mixing, an industrially scalable and solvent-free processing route. Mechanically and chemically functionalized biochar was incorporated to enhance filler dispersion and interfacial interactions with the polymer matrix. The effect of biochar functionalization on the structural, thermal, mechanical, and biodegradation behavior of PBS was systematically investigated. Crystallization behavior and thermal transitions were analyzed using differential scanning calorimetry (DSC) and X-ray diffraction (XRD), while tensile testing was employed to assess mechanical performance. The results show that appropriately functionalized biochar enhances stiffness, thermal stability, and crystallinity of PBS at low filler contents, indicating effective reinforcement and nucleation effects. These property enhancements, together with controlled biodegradation behavior, highlight the potential of PBS/biochar composites for sustainable coating applications requiring balanced performance and environmental compatibility.

Acknowledgements

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Enhanced Visible-Light Photocatalysis Using TiO_2/C_3N_4 Composites for Indoor Air Quality Improvement

sciforum-167175

online as poster presentation (without DOI)

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As people spend around 70–90% of their time indoors, poor indoor air quality represents a major health concern, mainly due to the emission of volatile organic compounds (VOCs) from multiple sources. Conventional air purification technologies primarily remove particulate matter, whereas photocatalysis degrades pollutants into harmless products. Titanium dioxide (TiO_2) nanoparticles are widely employed as photocatalysts due to their stability, low cost, and non-toxicity. However, their application is limited by UV-light activation and high electron–hole recombination rates. To overcome these limitations, TiO_2–C_3N_4 composites were developed to extend light absorption into the visible region and improve charge separation.

TiO_2–C_3N_4 composites with different mass ratios were synthesized using a simple ball-milling method. The materials were characterized by N_2 physisorption, X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), thermogravimetric analysis (TGA), and scanning electron microscopy (SEM). Photocatalytic activity was first evaluated under visible light in aqueous medium using a standard organic dye. The most efficient composite was subsequently immobilized and tested in a gas-phase photocatalytic system.

The TiO_2/C_3N_4 composites exhibited low specific surface area and a higher anatase-to-rutile ratio, thereby enhancing photocatalytic performance. The composite containing 0.9 g TiO_2 and 0.1 g C_3N_4 exhibited the highest activity under visible light in liquid medium, achieving 70% degradation. Importantly, this material maintained high photocatalytic efficiency after immobilization and under gaseous conditions, demonstrating its potential for indoor air purification. These results highlight TiO_2–C_3N_4 composites as a promising and cost-effective solution for improving indoor air quality under visible light.

Fabrication of fluorine-free superhydrophobic coatings via sol-gel method and spray deposition

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Superhydrophobic surfaces have marked increased attention in materials science due to their potential applications in self-cleaning, anti-corrosion, water-repellent, and antimicrobial technologies. Conventional coatings often rely on fluorinated compounds, which raise environmental and health concerns due to bioaccumulation. In this study, a sustainable method was developed to produce silicon-based superhydrophobic coatings via an one-step sol-gel process, applied through a spray-deposition technique using non-toxic solvents. The aim is to fabricate environmentally friendly coatings with high water contact angles on various substrates, offering a safer and effective alternative to fluorinated systems. In this study, a one-step sol-gel synthesis was used to prepare a low-viscosity organosilane solution using tetraethyl orthosilicate (TEOS) and hexadecyltrimethoxysilane (HDTMS) as the primary precursors, with ethanol and water as solvents. The solution was stirred at 60 °C to promote hydrolysis and ensure homogeneous mixing, resulting in a stable sol suitable for coating deposition. The coatings were deposited via a spray-deposition technique that is low cost and easily scalable for industrial use. A wide range of substrates—including paper, metals (Ti6Al4V, Al 1050 H14), plastic, cardboard, fabric, and brick—were coated to demonstrate the versatility of the method. Process parameters such as catalyst type and precursor ratios were optimized to ensure uniform deposition and achieve the highest contact angle with low contact angle hysteresis. Surface morphology was examined using scanning electron microscopy (SEM), while Fourier-transform infrared spectroscopy (FTIR) verified the chemical structure. Water contact angles were measured to confirm the superhydrophobic property of the coated surfaces. For Ti6Al4V, the contact angle reached approximately 164°, with contact angle hysteresis below 2°, as further confirmed by self-cleaning tests on the coated surface. Other substrates exhibited contact angles between 151° and 164°, along with effective self-cleaning performance.

Migration and Safety Assessment of Bio-Coating for Frozen Fish Packaging

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Corrugated cardboard is a sustainable alternative for frozen food packaging, but concerns remain regarding barrier performance and substance migration. This study assessed overall migration and the potential transfer of cytotoxic substances from a beeswax–chitosan antimicrobial coating intended for frozen Atlantic cod packaging.

Overall migration was evaluated on coated and uncoated cardboard using TENAX in stainless steel migration cells for 10 days at 40 °C, in accordance with EN 1186. Migration values were 0.233 ± 0.047 mg/dm² for uncoated cardboard and 0.567 ± 0.047 mg/dm² for coated samples, remaining well below the legal limit of 10 mg/dm² established by EU Regulation 10/2011.

To verify compliance with EDQM 2021 requirements for active packaging, agar diffusion tests were performed to assess the transfer of cytotoxic or antimicrobial compounds. Coated and uncoated samples were tested alongside antibiotic controls on agar plates inoculated with *Bacillus subtilis* and incubated for 72 h. No inhibition zones were observed for coated samples, indicating no compound transfer.

These results demonstrate that the bio-coated corrugated cardboard exhibits controlled migration behaviour and meets current European regulatory requirements, supporting its potential application as sustainable packaging for frozen fish products.

Nanoparticle enhanced sol-gel coatings for erosion and fouling resistance in offshore wind turbine applications: A comparative study of metallic and carbon reinforcements

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online as oral presentation (without DOI)

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Offshore wind turbine blades are significantly affected by rain erosion, particulate impacts, and biofouling, leading to surface degradation, increased aerodynamic drag, and higher maintenance costs, thereby hindering wind energy decarbonisation goals. Addressing this challenge requires developing coating solutions that offer improved resistance to wear and biofouling, manufactured through eco-friendly, energy-efficient processes. The study introduces silica-based hybrid sol-gel coatings reinforced with metallic and carbon nanoparticles, providing a sustainable route to the creation of mechanically robust, hydrophobic surfaces for glass-fiber reinforced polymer (GFRP) wind turbine blades.

Tetraethylorthosilicate (TEOS) based sol-gel formulations containing 0.1wt% commercially available silver nanoparticles (AgNPs) and multi-walled carbon nanotubes (MWCNTs) were synthesised, applied to GFRP substrates via dip-coating, and thermally cured at 120°C for 2 hours.

Material characterisation confirmed that the MWCNT-enhanced sol-gel coatings exhibited higher mechanical, thermal, and surface properties compared to the AgNPs formulation. Attenuated Total Reflectance Fourier Transform Infrared (ATR-FTIR) spectroscopy analysis confirmed strong Si-O-Si network formation, with MWCNTs creating a denser structure. Water contact angle (WCA) measurements confirmed an increase in hydrophobicity with the addition of MWCNTs, effectively controlling surface energy. The TGA results showed improved thermal stability of MWCNT coatings, with lower mass loss compared to AgNPs coatings. Differential scanning calorimetry (DSC) confirmed thermal stability up to 300°C for both formulations.

Nanoindentation showed significant mechanical enhancement, with MWCNT-reinforced coatings exhibiting 26% higher hardness (0.400 vs. 0.318 GPa), a higher elastic modulus (3.24 GPa), and reduced indentation depth, indicating superior load-bearing capacity and deformation resistance. Furthermore, a preliminary droplet impact erosion test (DIEM) was performed for short periods to evaluate resistance to rain impact. Additionally, antimicrobial activity was assessed as an initial indicator of anti-fouling potential.

The study demonstrates that carbon-based nanomaterials outperform metallic nanoparticles in producing durable, hydrophobic coatings for renewable energy applications.

PFAS-free sol-gel hybrid coatings for sustainable cookware, glass and food-packaging equipment

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online as oral presentation (without DOI)

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The pervasive use of per- and poly-fluoroalkyl substances (PFAS) in non-stick, anti-soiling and water-repellent coatings has generated growing concerns over their toxicity, persistence and bio-accumulation. In response, the TORNADO and PROPLANET projects have pursued sol-gel-based, PFAS-free hybrid coatings that simultaneously meet the demanding functional, mechanical and aesthetic requirements of kitchenware, low-maintenance glass and food-packaging machinery.

In the TORNADO line, a ceramic–organic network is generated by hydrolysis and condensation of metal alkoxides combined with siloxane organofunctional groups and silicon oils. Optimised precursor ratios yield a two-layer system (base-coat + top-coat) that can be sprayed onto aluminium pans. The resulting film is homogeneous, hydro- and oleo-phobic (SFE ≈ 25 mN/m), scratch-, impact- and abrasion-resistant, corrosion-proof and stable at cooking temperatures up to 300 °C.

Parallel work in PROPLANET has produced two sol-gel-based families of coatings. (i) Transparent hybrid films for glass provide durable hydrophobic and anti-soiling performance, suitable for automotive windows and shower doors. (ii) PFAS-free, functionalised hybrids for food-packaging machines deliver non-stick, anti-wear behaviour together with high-temperature resilience. Systematic screening of chemistries and functional groups, together with contact-angle measurements (water/hexadecane) and standard mechanical tests, confirms omniphobic surface free energies and long-term durability under service-relevant conditions.

These results demonstrate that sol-gel chemistry enables the design of environmentally benign, high-performance coatings, offering a viable pathway to replace PFAS in diverse consumer and industrial applications while supporting circular-economy value chains.

Phosphorus- and Nitrogen-modified lignin additives for multifunctional polymer coatings

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online as poster presentation (without DOI)

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The increasing demand for sustainable, multifunctional coatings has driven research toward bio-based additives capable of enhancing thermal stability, durability, and long-term performance while reducing environmental impact. In this work, Kraft lignin was chemically modified with phosphorus (P), nitrogen (N), and combined phosphorus-nitrogen (P-N) elements and evaluated as a multifunctional bio-based additive in high-density polyethylene (HDPE) matrices. The modified lignins were incorporated into HDPE at loadings ranging from 1 to 30 wt% via melt processing, and the resulting materials were systematically characterized with respect to thermal behavior, oxidative stability, flame retardancy, mechanical performance, and surface properties. P- and N-functionalized lignin significantly enhanced char formation and increased the temperature of maximum thermal degradation, indicating improved thermal protection mechanisms. UL-94 vertical burning tests revealed reduced melt dripping and prolonged burning times compared to neat HDPE, confirming the effectiveness of lignin-based additives in mitigating flammability. At low additive loadings (≤5 wt%), the composites maintained or slightly improved mechanical properties, while higher loadings led to a gradual reduction of properties, associated with filler aggregation. Furthermore, the composites exhibited markedly improved antioxidant performance, as evidenced by extended oxidation induction times and enhanced DPPH radical scavenging activity, highlighting their potential for improved aging resistance in protective coatings. Contact angle measurements demonstrated that the incorporation of modified lignin maintained or improved surface hydrophobicity, a key surface property for polymer-based coating applications.

Sol-Gel Oxide Barrier Coatings on PET Substrates for High-Pressure Hydrogen Storage Applications

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online as poster presentation (without DOI)

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The transition toward a hydrogen-based economy necessitates the development of advanced materials capable of mitigating hydrogen permeation in Type IV high-pressure storage tanks. This study investigates the synthesis and characterization of silica-based barrier coatings produced via the sol-gel method and applied to PET substrates.

Permeability tests were conducted across a wide pressure range, from low-pressure conditions (2 bar) to high-pressure environments (400 bar). Results demonstrate that the amorphous silica network significantly enhances its barrier properties. Moreover, it was shown that modifications introduced to the silica network, such as doping or aging, improve the barrier properties of the coatings even more. Tests revealed a significant reduction in the permeability coefficient for multilayered and doped coatings, with some samples showing up to 40% improvement in gas transmission rate compared to standard configurations. These findings highlight the strong potential of sol–gel-derived silica-based coatings as effective barrier solutions for next-generation hydrogen storage systems, contributing to improved safety, durability, and performance of Type IV tanks.

Surface-Engineered PLA-Based Nanoparticles via Folic Acid–Functionalized Chitosan Coatings: Performance Evaluation and Targeted Drug Delivery Potential

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online (without DOI)

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Surface engineering of biodegradable polymeric nanoparticles offers an effective strategy to regulate interfacial properties, biological interactions, and functional performance in advanced coating systems. In this work, poly(D,L-lactic acid) (PLA)-based nanoparticles were surface-engineered using a folic acid–functionalized chitosan (CS-FA) coating, creating a hybrid organic architecture that integrates biodegradability, biofunctionality, and receptor-specific surface recognition.

The impact of the CS-FA coating on surface and coating performance metrics was systematically investigated. Structural and chemical modification were confirmed by FTIR and NMR spectroscopy, while particle morphology and coating integrity were evaluated by SEM and DLS. Key interfacial properties, including wettability and enzymatic degradation, were assessed under physiological conditions (pH 7.4), demonstrating that FA-functionalized chitosan coatings impart enhanced surface hydrophilicity, a feature that can directly influence diffusion characteristics and stability of the coated nanoparticles. Furthermore, to evaluate biointerface performance, in vitro studies were conducted using immortalized mouse embryonic fibroblasts (iMEFs) and MDA-MB-231 breast cancer cells. Cytocompatibility was confirmed across all formulations, while confocal laser scanning microscopy revealed enhanced cellular association and internalization of CS-FA–coated nanoparticles in MDA-MB-231 cells, attributed to folate receptor–mediated interactions. In contrast, minimal nonspecific uptake was observed in iMEFs, indicating surface-selective behavior.

Overall, the study demonstrated how folic acid–functionalized chitosan coatings can be used to surface-engineer PLA-based nanoparticles with tunable interfacial properties and selective biological interactions. The findings highlight the potential of hybrid organic coatings to simultaneously optimize coating performance and enable targeted drug delivery functionalities within a safe and sustainable materials design framework.

Sustainable Fluorine-Free Hydrophobic Solutions to Prevent Paint Overspray Adhesion

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online as poster presentation (without DOI)

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An important challenge faced by the automotive industry concerns the so-called overspray, when excess paint particles disperse and contaminate the surrounding environment. To minimise the potential damage caused by overspray to the painting robots, these are often protected by polyester covers. However, their hydrophilic nature leads to paint absorption, requiring their often replacement and subsequent waste generation. A promising solution to deal with this problem is to impart the covers with superhydrophobic properties. In superhydrophobic surfaces, the drops of water are almost spherical, so they will readily roll off. When exposed to paint particles, the paint should behave similarly, not having time to be absorbed.

In this work, several modification strategies were explored to impart polyester fabrics with highly hydrophobic features through the combination of nanomaterials (silica and alumina nanoparticles) to introduce a micro/nano roughness and the use of low surface free energy compounds (stearic acid and hexadecyltrimethoxysilane). Results showed that, overall, the immobilisation of polyester samples with nanomaterials alone increased the water contact angle, but the water droplets did not roll from the surfaces. Such hydrophobic features were attributed to the increase in fibres' roughness, as evaluated by SEM analysis and roughness measurements. When nanomaterials were combined with hydrophobic agents, the hydrophobic properties of polyester fabrics improved synergistically, as evidenced by the increase in the water contact angle but also by the decrease in the water sliding angles. It was also possible to conclude that any of the modification strategies improved the fabric's ability to resist the effects caused by overspray, as there was a significant reduction in the amount of paint absorbed. Results also suggested that the approaches with the lowest sliding angles had better resistance against the effects caused by overspray. The durability of the best effective treatment was evaluated by measuring the water contact angle after 70 washing cycles, and results showed that hydrophobicity could be preserved even after being subject to these harsh conditions.

In conclusion, combining nanostructured materials with hydrophobic agents holds great potential to create highly hydrophobic features and subsequent resistance to overspray. This minimizes the need for frequent replacements, reduces painting process delays and costs and reduces the waste produced.

The EnWaRec project: development of antiscaling and anticorrosion coatings for steel mill cooling water circuit

sciforum-164596

online as oral presentation (without DOI)

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The EnWaRec project addresses the nexus between energy and water in hydrogen-based steelmaking by implementing with an holistic approach the recovery of waste heat and water from cooling and gas washing circuits including internal energy and water reuse. To overcome traditional barriers of fouling, scaling, and corrosion, the project integrates real-time process monitoring, thermally stable chemical treatments, and specialized anti-wear coatings. These innovations enable the use of microturbines for hydropower, high-temperature heat pumps for steam generation, and membrane distillation for water recovery. By optimizing these processes through predictive simulation software, EnWaRec will provide technologies and tools opening recovery of waste heat and water.

RINA-CSM in EnWaRec intends to model ADI Steel producer cooling water circuit plant. The model evaluates maximum energy extraction and micro-turbine operating ranges using real-time industrial data and simulations. Moreover, will be tested and defined steel materials suitable for industrial water circuit by electrochemical tests as Open circuit potential (OCP) and polarization curves measurements in electrolyte simulating ADI industrial water.

Tailored silicon alkoxides (as TEOS, GPTMS) based sol-gel coatings will be developed for applications to prevent scaling and corrosion on heat exchangers surfaces, cooling nozzles and turbine inner parts. The aim is to achieve very thin coatings, with low wettability, also adaptable to complex component geometries. The thin layer will not impact the flow and the section of the turbine inner parts and cooling nozzles. Moreover, the low wettability will disfavour the settlement and growing of scaling and corrosion agents of the industrial water on heat exchangers, maintaining heat transfer efficiency.

The authors are presenting this work on behalf of the EnWaRec Consortium

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The impact of measurement geometry on colorimetric properties of coatings based on cellulose nanocrystals (CNCs) and pearl luster pigments

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online as poster presentation (without DOI)

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This study investigates colorimetric behaviour of sustainable coatings fabricated using cellulose nanocrystals (CNCs) as a biopolymeric binder and different types of pearl luster pigments, which differ in chemical composition, pigment color, and particle size. Coatings that combine high-performance CNCs with pearl luster pigments, which impart angle-dependent color (iridescence) due to their optically thin layers, offer a unique optical effect driven by the interplay of structural color and pigment-based reflection. The black paper was double coated in machine direction using K Control Coater. Colorimetric values (CIELAB) and spectral reflectance (R%) of the coating were measured across the visible spectrum from 400 to 700 nm, with a fixed illumination angle of 45° and viewing angles of -15°, 15°, 25°, 45°, 75°, and 110°. Results reveal pronounced shifts in reflectance intensity and CIELAB values with changing viewing angle, driven by the type of pearl luster pigments and their orientation. The findings provide insight into the design of sustainable, visually dynamic coatings for decorative and functional applications, where controlled angular color variation is desirable.

Toward Sustainable Ice Protection: Photothermal and Icephobic Polyurethane Nanocomposite Coatings

sciforum-164177

online as oral presentation (without DOI)

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Abstract

Ice accumulation on engineering surfaces operating in cold environments presents persistent safety, performance, and economic challenges across sectors such as aerospace, wind energy, transportation, and power infrastructure. Conventional de-icing strategies, including mechanical removal, chemical agents, and resistive heating, are often energy-intensive, costly, and environmentally harmful. In this context, polyurethane (PU)-based photothermal coatings offer a promising alternative by combining mechanical durability, environmental compatibility, and multifunctional ice-mitigation capability.

This study presents a simple and scalable strategy to develop multifunctional PU coatings with enhanced anti-icing and de-icing performance through the incorporation of iron oxide (Fe_3O_4) nanoparticles with tailored surface chemistry. Three nanoparticle systems were investigated: unmodified Fe_3O_4 (FPU), silicone oil–coated Fe_3O_4 (SiFPU), and hydroxyl-functionalized Fe_3O_4 (FOHPU), with loadings ranging from 0.5 to 10 wt%. The influence of nanoparticle functionalization on mechanical integrity, photothermal conversion efficiency, and icephobic behavior was systematically evaluated.

The coatings were fabricated and characterized using scanning electron microscopy (SEM), Fourier-transform infrared spectroscopy (FTIR), UV–Vis spectroscopy, and tensile testing. Photothermal performance was quantified via infrared thermography under 1-sun xenon illumination. Icephobic behavior was assessed using ice push-off tests conducted in a controlled cold-room environment, both with and without simulated solar irradiation. Coating durability was evaluated through repeated icing/de-icing cycles to assess long-term performance stability.

UV–Vis spectroscopy revealed significantly enhanced light absorption in nanoparticle-modified coatings, with silicone oil coating and hydroxyl functionalization reducing the Fe_3O_4 band gap by 2.3 and 2.55 eV, respectively. Surface-functionalized nanoparticles markedly improved icephobic performance. The 10FOHPU coating exhibited superior mechanical properties, achieving a Young's modulus of 140 ± 6.2 MPa and a tensile strength of 6.3 ± 0.2 MPa, compared to 106.1 ± 4.1 MPa and 6.1 ± 0.4 MPa for pristine PU. ATR-FTIR analysis at sub-zero temperatures confirmed the formation of a quasi-liquid interfacial layer on FOHPU coatings. Notably, the 10SiFPU coating demonstrated the lowest ice adhesion strength (40 ± 8 kPa) after 20 minutes of light exposure. These results demonstrate that tailoring nanoparticle surface chemistry within PU matrices enables a synergistic enhancement of mechanical robustness, photothermal efficiency, and icephobic performance, offering a sustainable and energy-efficient solution for advanced ice-mitigation applications.

Tyrosine-Modified surface coated Lignin as a Bio-Based Filler in HDPE matrix

sciforum-166196

online as poster presentation (without DOI)

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Lignin, the second most abundant natural polymer following cellulose, is receiving considerable interest as a renewable resource capable of diminishing dependence on fossil fuels and improving the environmental sustainability of polymer composites [1]. While unmodified lignin offers inherent benefits like thermal stability, flame retardancy and antioxidant properties, its poor compatibility with hydrophobic matrices often limits its incorporation to only a small amount. As a result, a variety of chemical modification strategies are utilized to produce value-added lignin derivatives, hence enhancing its applicability in green polymeric materials [2].

In this work, lignin modified with tyrosine (Lig-Tyr) was incorporated into the HDPE matrix via melt mixing at 190 °C, in five different loadings 1 wt.%, 5 wt.%, 10 wt.%, 20 wt.%, and 30 wt.%. The final composites were characterized in terms of their structure through Fourier-transform infrared spectroscopy (FTIR). Their thermal behavior was evaluated via Differential Scanning Calorimetry and revealed no significant alteration of the HDPE properties after lignin incorporation, while mechanical behavior was deteriorated especially in filler loadings higher than 10 wt.%. Finally, the investigation of antioxidant properties through the DPPH method suggested enhanced antioxidant capacity compared to the neat polymer.

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From Specification to Mechanism: Lessons from Coating Tribology

sciforum-181071

online (without DOI)

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This presentation argues that progress in coating tribology does not come from reproducing fixed specification values, but from understanding the underlying failure and contact mechanisms. Through several case studies, it shows how conventional specification-driven tests can give misleading or incomplete conclusions when applied outside their original context. Examples include soft polymer coatings on steel, where standard peel and scratch methods fail to detect true adhesion loss; TiN coatings in tribocorrosion, where static corrosion assumptions break down under dynamic sliding conditions; and hard chrome replacement, where matching hardness alone does not reproduce functional performance across different applications. Across these cases, the central lesson is that tribological behaviour is system-dependent, dynamic, and strongly influenced by the interaction between material, environment, and loading conditions. The presentation advocates a mechanism-based pathway for innovation: start from the real failure mechanism, reproduce it at laboratory scale, validate the method, and only then develop standards or specifications. For researchers, engineers, and policy makers alike, the message is clear: sustainable coating development and substitution require functional redesign rather than metric replication.

Impact of Deposit Homogeneity on Sunscreen Efficacy: A Novel Quantitative Method Using LC-OCT

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online as poster presentation (without DOI)

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Performance of sunscreens is primarily optimized through the development of their organic or mineral filtering systems, i.e. the core of their photoprotective action. However, numerous studies have underscored that the homogeneity of the applied deposit is also key to optimize the effectiveness of a given filtering systems. Quantifying the homogeneity of a coating present a significant challenge, particularly on complex substrates such as skin. Therefore, there is a key challenge in being able to have robust methods to measure deposit homogeneity for both *in vitro* and *in vivo* UV tests. This work, focused on developing new quantitative methods for evaluating sunscreen deposit and its homogeneity. Our approach involved adaptation Line-Field Confocal Optical Coherence Tomography (LC-OCT), a technique commonly used in biology, to precisely assess the thickness distribution of sunscreen deposit. For this study, we specifically investigated deposit modifications without changing the filtering system, thereby successfully linking variations in deposit thickness and homogeneity directly to filtration performances. This new method not only can be leveraged to advance the development and improvement of new photoprotective technologies but also paves the way for a more comprehensive understanding and characterization of sunscreen applications, both *in vivo* and *in vitro*, leading to improved protection.

Light-induced thermal drying process of sol-gel layers obtained by ultrasonic atomization

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Sol-gel coatings provide durable surface protection across automotive, construction, and industrial sectors. The global market was valued at USD 7.8 billion in 2022 and is projected to reach USD 16 billion by 2030, representing a 9.4% compound annual growth rate (CAGR). Automotive applications dominate this growth, with car window coatings alone expected to reach USD 6.5 billion by 2030 at an 11.9% CAGR. These coatings offer superior protection for various surface functions, making them increasingly critical for high-performance industrial applications.[1]

For research purposes, the most common method of preparation of sol-gel layers is dip-coating. However, this method poses challenges when it comes to large-scale and curvilinear surface substrates. Consequently, ultrasonic atomization has been proposed as a promising alternative: it forms uniform, thin sol-gel films from precisely controlled, ultrafine droplets without degrading the hydrolysate structure.[2] Ultrasonic atomization is based on ultrasonic vibrations that atomise substances from the liquid phase into a spray form, without any adverse chemical processes degrading the original hydrolysate. The size of the droplets is very fine, with volumes expressed in nanoliters, and their size distribution during ultrasonic spraying can be precisely controlled to form uniform thin films.[3]

While ultrasonic atomization effectively addresses challenges relating to deposition uniformity, the subsequent thermal stabilization of sol-gel layers remains energy-intensive. Conventional thermal curing typically requires elevated temperatures and extended processing times, creating significant barriers for heat-sensitive substrates and high-throughput manufacturing. To address these limitations, we propose light-induced thermal drying as an energy-efficient stabilization method that reduces energy consumption while maintaining coating performance.

In this study, sol-gel coatings were deposited using ultrasonic atomization and subsequently stabilized by light-induced thermal drying process. Controlled light radiation primarily functions as a thermal energy source to promote solvent evaporation. A dedicated photothermal drying stand enable simultaneous irradiation and temperature control. The resulting layers are evaluated to assess the feasibility of light-assisted thermal drying as a low-energy alternative to the industrial sol-gel coating process.

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High-Energy Ball Milling for the Synthesis and Liquid Predispersion of Nanoparticles

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online as oral presentation (without DOI)

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The availability of nanoparticles in a form suitable for industrial processes remains a key limitation for the deployment of nanocomposite coatings. This work presents the scaling of high-energy ball milling (HEBM) as a combined route for nanoparticle synthesis, size refinement, and direct predispersion in liquid media, enabling the production of concentrated, ready-to-use nanoparticle masterbatches.

High-energy ball milling was adapted from laboratory to pilot scale to process ceramic nanoparticle systems, with a primary focus on SiC and Al_2O_3. The approach allows simultaneous particle size reduction and deagglomeration while promoting effective wetting and stabilisation in liquid carriers. The resulting masterbatches exhibit narrow particle size distributions, reduced agglomeration tendency, and long-term colloidal stability, enabling straightforward dosing into downstream processes without additional dispersion steps or handling of dry powders.

In addition to the demonstrated systems, other carbide-based nanoparticles, including TiC and B_4C, showed strong potential when processed via the same methodology. Their intrinsic mechanical properties indicate suitability for advanced nanocomposite applications.

The scaling of HEBM for liquid predispersion provides a robust and versatile pathway for supplying industrially relevant nanoparticle masterbatches. This contribution highlights how process engineering of nanoparticle production and formulation can bridge the gap between nanomaterial development and practical industrial use.

Recycling of dispersion-coated paper-based packaging: tracking methodology to discover and quantify microplastics

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online (without DOI)

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The increasing diffusion of dispersion-coated fiber-based packaging has created a growing need for advanced analytical methodologies capable of assessing coating integrity and degradation during recycling. In this work, we introduce a process-integrated method designed to detect, isolate, and characterize microplastic (MP) fragments generated from thin polymeric films during hydropulping. The approach combines controlled laboratory repulping, aligned with industrial conditions, with a multi-stage isolation workflow based on sequential filtration and fine-mesh screening, taking and adapting standard methodologies recognized and used within the sector.

To enhance traceability, selected coating formulations were tagged with rhodamine-B, enabling semi-automated MP detection through complementary imaging techniques including fluorescence microscopy, optical microscopy, and Raman spectroscopy. These instruments supported cross-validated identification of polymeric particles and allowed characterization of fragmentation behavior down to 20 µm. For a representative 8 g/m² thin-film coating, over 75,000 secondary MPs were recovered from solid residues, with an average equivalent diameter of 75.4 µm and a particle density of 4.7 particles/mm². The study demonstrates how this integrated platform enables the systematic evaluation of thin-film fragmentation pathways during repulping.

Because this work represents one of the first attempts to apply such an approach to coated fiber substrates, the tests are best understood as preliminary applications of the methodology, illustrating its diagnostic potential rather than providing exhaustive environmental metrics. The framework is inherently scalable and reproducible, offering a powerful foundation for equipment benchmarking, coating-failure analysis, and process-control improvement across recycling and coating-development environments.

Overall, the methodology establishes a new analytical capability for the coating community, supporting Safe and Sustainable by Design (SSbD) strategies aimed at developing next-generation, high-performance, and recyclability-oriented barrier coatings.

Composite Resins with Self-Activating Properties for Direct Electroless Metallization of 3D Printed Components

sciforum-164736

online as oral presentation (without DOI)

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3D printing, or additive manufacturing, is one of the most impactful technologies in recent decades. It relies on the layer-by-layer fabrication of three-dimensional objects from digital models, unlike traditional subtractive techniques that shape parts by material removal. This approach enables high precision, design flexibility, reduced material waste, rapid prototyping, and the realization of complex geometries difficult to obtain with conventional manufacturing.

Despite these advantages, the most widely adopted and cost-effective 3D printing technologies, such as Fused Deposition Modeling (FDM) and Digital Light Projection (DLP), are largely limited to polymeric materials. This aspect drives the development of efficient and cost-effective metallization strategies able to impart metallic properties to 3D printed polymer components. Among available solutions, wet metallization techniques based on liquid electrolytes are particularly attractive in terms of cost and scalability.

A particularly promising way to carry out wet metallization on 3D printed parts is represented by the use of self-activating materials. These materials can be directly 3D printed and incorporate either a catalytic metal or a precursor of a catalytic species, such as a metal salt. When a precursor is used, it can be converted into the active catalyst through chemical reduction. Embedding the catalytic species within the printed part removes the need for the etching and surface activation steps typical of standard electroless plating, providing improved adhesion, coating uniformity and the possibility of selective metallization.

In the present work, self-activating composites containing non-precious transition metal salts are developed, 3D printed, and metallized. Nickel and copper salt microparticles are dispersed in a DLP resin to obtain printable composites. After printing, surface-exposed precursors are chemically reduced to form metallic nuclei, which initiate the electroless deposition of NiP and Cu. The resulting coatings are characterized in terms of adhesion, uniformity, and morphology. The possibility of achieving selective metallization is demonstrated as well.

Life Cycle Assessment and Costing of Metal Plating Processes on Resin-Based 3D Printed Components

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The adoption of additive manufacturing, particularly resin-based 3D printing, has enabled rapid production of complex geometries for industries such as automotive, aerospace, electronics, biomedical devices, and increasingly in jewelry applications. Metal plating of 3D printed resin components is increasingly used to enhance mechanical, thermal, and electrical properties, extending their applicability in demanding industrial environments. However, the environmental and economic impacts associated with these processes remain largely unexplored. This study presents a comparative Life Cycle Assessment (LCA) and preliminary Life Cycle Costing (LCC) of electroless metal plating on resin-based 3D printed articles. Two 3D printing methods were considered, followed by post-printing treatment (curing and cleaning), pre-treatment, and a multi-step etching and activation process before electroless deposition of metals including Cu, Au, Ag, and Ni-P. The etching process, particularly sensitive to metal type and resin formulation, was analyzed as a critical contributor to both environmental impact and production cost.

The LCA framework (following ISO 14040/44 guidelines, implementing the Environmental Footprint (EF) 3.1 (2022) methodology) is applied and compares scenarios involving different printing technologies, metal types, and etching conditions, identifying environmental “hot spots”. The LCC analysis complements the LCA by evaluating material consumption, processing steps, energy use, and waste management for each scenario, aiming to identify trade-offs between environmental performance and economic feasibility and highlighting key cost drivers. Life Cycle inventory (LCI), apart from available secondary data, is also supported by primary ones (real pilot-scale data) provided by CREATIVE NANO, ensuring practical relevance and validation of the results.

By integrating LCA and LCC, this study provides a holistic understanding of the sustainability and cost drivers of metal plating on 3D printed resin substrates. The results are expected to support industrial process optimization, sustainable material selection, and economically responsible adoption of advanced manufacturing technologies.

Micro-forging as a means for improving interlayer and surface mechanical properties in additive manufacturing

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online as oral presentation (without DOI)

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Additive manufacturing processes are nowadays widely used for prototyping, as well as for industrial applications, e.g. the production of machine tools. The finished products often suffer from degraded mechanical properties comparatively, as additive manufacturing processes inherently create mechanical property variations among layers. Issues commonly arise due to incomplete fusion, thermal cycling, contamination, anisotropy, porosity and cooling rate variations.

A few different methods have been introduced for both metallic and synthetic materials, which typically include annealing or work hardening. These can be applied to the finished product or during the manufacturing process to improve the interlayer mechanical properties. Regarding work hardening, deep rolling is a common procedure where a spherical indenter is rolled onto the manufactured surface using a controlled force applied perpendicular to the surface. However, this procedure is generally coarse and mostly designated for large surfaces.

We herein introduce micro-forging with the aid of a controlled repetitive impact indenter, to induce precise levels of work hardening onto manufactured surfaces. The force amplitude perpendicular to the treated surface can be adjusted according to the desired level of work hardening. The indenter, made of hard materials like tungsten carbide, hits the processed surface repeatedly at an adjustable rate. The kinematics are completed by either moving the indenter onto the surface or the workpiece underneath the indenter. By adjusting the impact repetition rate and the feed of the surface underneath the indenter, impact overlapping can be achieved and the resulting mechanical properties optimized. The shape of the indenter can also be freely selected for different applications or for creating a texture finish.

Our findings illustrate that interlayer hardness can be drastically increased leading to more robust machine elements. Surface roughness can be adjusted, especially important for further processing like the subsequent application of coatings. Issues arising from increased porosity can be minimized, as the introduced micro-forging process helps to minimize the overall gaps between the material.

Role of substrate hardness on the adhesion of DLC-based coatings deposited on L-PBF Al-Si-Mg alloys

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Diamond-Like Carbon (DLC) films are employed to improve the sliding wear performance of tribosystems, including those used in the automotive and aerospace sectors. Recently, Al- and Ti- based additively manufactured materials have gained increasing interest in these sectors due to their high strength/density ratios. However, their relatively low hardness affects their wear resistance unless coatings are applied. DLC-based films offer a potential solution, but the softness of these substrates could represent an issue. Indeed, when the substrate is more elastically and plastically compliant than the film, the latter could experience excessive deformation, leading to failure.
In this work, we studied the effect of substrate hardness on the adhesion and wear behaviour of PVD and PA-CVD DLC-based coatings deposited onto AlSi10Mg and AlSi7Mg alloys produced via Laser Powder Bed Fusion (L-PBF) and subjected to different heat treatments. The unique microstructure of L-PBF materials indeed allows non-conventional heat treatments that result in a wide range of achievable properties. Specifically, we considered substrates in four different conditions: as-built, directly aged, solution-treated, and T6 (solutionized and aged). As the hardness of the substrate decreased due to increasing reorganization and coarsening of the fine cellular network of eutectic Si, the fraction of delaminated coating area in the Rockwell indentation test increased, and the delamination load in the scratch test decreased. In the ball-on-disc test, the DLC top layer followed the plastic deformation experienced by all substrates under the contact stress. In contrast, the WC/C intermediate layer cracked and caused localized film spallation, with greater severity on softer substrates. The additional stress concentration caused by the random presence of open surface pores on L-PBF substrates promoted larger spallation or delamination whenever the wear trace passed through one of them. After the T6 treatment, the extensive reduction in hardness led to systematic coating delamination.

The CoBRAIN project – an overview

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online as oral presentation (without DOI)

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The goal of the "CoBRAIN" project is to design novel coating formulations for protection against wear and corrosion using an integrated materials development workflow. We aim to replace existing coatings which employ toxic, carcinogenic substances either as raw materials (e.g. chromium electroplating from CrO_3 solutions in water) and/or as constituents of the final product (e.g. cobalt in Stellite alloys and WC-Co hardmetals) and/or employ critical raw materials, such cobalt itself or tungsten. We specifically focus on the novel class of High-Entropy Alloys (HEAs), i.e. nearly equiatomic alloys made of four, five or six elements, employing these alloys either for purely metallic coatings or as matrices for hardmetal coatings, combined with TiC as hard phase.

To explore a vast range of possible compositions, we combined various high-throughput physical modelling techniques to simulate properties such as the equilibrium crystalline phase(s), the stacking-fault energy, the microstructural evolution, and the micromechanical properties of HEAs, and then we trained neural network-based AI models on this extensive dataset. We also developed high-throughput laboratory methods to provide as much input and validation data as possible for these models. An overarching ontology allowed semantic mapping of the dataset into a cloud-based knowledge base to ensure interoperability.

The main results obtained by the CoBRAIN project so far have been:

Contributing, to the creation of an improved version of the EMMO ontology for the mapping and storage of data and metadata.

Creating an AI-based API to predict the properties of a given HEA composition, or identify candidate HEA compositions based on predefined targets.

Setting up an LCPA tool to estimate the costs, environmental impact and health hazards of each novel formulation in comparison to benchmark materials.

Developing a sustainable decision support system based on the integration of the AI and LCPA tools, which is now available for demonstration and trial by the project partners and interested stakeholders.

Gaining experience on the actual production of HEA-based feedstock powders and of coatings by thermal spraying processes. This is now being scaled-up to industrial case-studies.

The Role of Standardization in Research and Innovation projects: Case study of Ni-based materials testing for energy applications

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online as poster presentation (without DOI)

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The use of standardisation in research and innovation projects aims to increase the impact and significance of the results obtained by including them in new standards. By translating validated research outcomes into pre-normative and normative documents, standardization facilitates reproducibility, comparability, and industrial uptake of emerging technologies, while supporting regulatory alignment and risk-informed decision-making. This is in line with the European Policy on Knowledge Valorisation and the ERA Code of Practice on Standardisation, which recommend using tools such as standardisation, among others, to make research results benefit economic activity, welfare and safety in Europe.

Within this context, the NICKEFFECT project integrates standardization as a strategic activity to maximize the impact of its scientific results in the field of non-noble metal-based coatings and electrodes for hydrogen generation. The involvement of UNE (Spanish Association for Standardization) a leading European standardization body with extensive experience in R&I projects, enabled the systematic identification and prioritization of project outputs with high standardization potential. Several pre-normative topics were evaluated, leading to the selection of the most industrially relevant topic as the technical basis for a CEN-CENELEC Workshop Agreement (CWA).

The resulting CWA 18302, *“Electrochemical characterisation at laboratory scale of non-noble porous metal-based electrodes for hydrogen generation in acidic medium”*, developed under the technical leadership of CIDETEC, provides harmonized recommendations for laboratory-scale electrochemical characterization. The work addresses key methodological aspects relevant to porous metal coatings, including test conditions, performance metrics, and data reporting, with particular attention to durability, activity, and reproducibility. By establishing a common characterization framework, the CWA supports SSbD principles by enabling consistent assessment of performance-sustainability trade-offs and facilitating comparability across research and industrial laboratories and integration of the research data into the decision support tools.

This contribution demonstrates how standardization can act as an effective bridge between advanced materials research, SSbD objectives, and industrial implementation, particularly for emerging coating technologies aimed at sustainable hydrogen production.

Bridging Safety, Functionality, and Sustainability in Surface Engineering: Lessons from ASINA and SUNSHINE EU Projects

sciforum-183080

online (without DOI)

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The transition toward a toxic-free and circular economy necessitates a paradigm shift in the development of advanced coatings, Safety and Sustainability must be integrated alongside technical performance from the very beginning. This presentation explores how the Safe and Sustainable by Design (SSbD) framework has been translated into practice through two major European Horizon 2020 projects: ASINA and SUNSHINE.

In the context of the ASINA project, we demonstrated how design strategies were applied to develop high-performance antimicrobial and photocatalytic textile coatings. The core of the approach lies in the definition of a multidimensional "Design Space", where Key Decision Factors (KDFs), such as water-based, room-temperature synthesis and specific deposition parameters (spray coating), were systematically managed. These KDFs were mapped against a "Performance Space" defined by Key Performance Indicators (KPIs), including antimicrobial efficacy (100% bacterial depletion and DeNOx abatement), worker exposure levels, and nanomaterial release during the product's life cycle. The selection of the most promising SSbD solutions, notably Ag-hydroxyethyl cellulose (AgHEC) and nitrogen-doped TiO_2, was supported by the ASINA Expert System (ES), a multi-objective optimization tool designed to balance safety, functionality, and cost-effectiveness.

In parallel, one of the case studies developed by the SUNSHINE project addressed the challenge of replacing hazardous PTFE-based anti-stick coatings in the bakery industry. A tiered SSbD approach led to the development of multicomponent nanomaterials (MCNMs), specifically core-shell structures like $SiC@TiO_2$ (Tier 1) and its further optimized alternative $SiC@SiO_2$ (Tier 2). The study highlights how modifying shell synthesis led to a 50% reduction in environmental impact and a 7% decrease in production costs, while ensuring strict compliance with EU food contact regulations through minimized ion migration.

By synthesizing the outcomes of both projects, this talk will illustrate how the integration of Life Cycle Assessment (LCA), exposure science, and early-stage toxicological screening can drive industrial innovation. The discussion will provide a strategic perspective for designing the next generation of coatings that meet industrial standards without compromising human health or environmental integrity.

Decision Support Tool for selection of SSbD metallic coating alternatives

sciforum-164116

online as poster presentation (without DOI)

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Coating solutions containing chemicals are frequently employed in many surface finishing industries even though they do not adhere to regulations encouraging safer and more sustainable options. Hard Chromium (HC) coatings are extensively used in multiple sectors such as manufacturing, automotive and machinery fields because of their outstanding mechanical and wear characteristics yet they remain hazardous. To address this challenge the EU-supported MOZART project creates coating technologies offering safe and eco-friendly substitutes for HC delivering the same or better performance while removing harmful chemicals and minimizing environmental harm.

Within this framework Safe and Sustainable, by Design (SSbD) methods are implemented. SSbD provides a structure addressing chemical safety, performance, recyclability and overall product sustainability. To convey the insights developed during the project to the target audience we introduce the MOZART Decision Support Tool (DST) a platform that helps users assess and choose sustainable coating options. The DST integrates SSbD. Delivers detailed data, on materials, coating characteristics, LCA, LCC and toxicity effects.

By means of scenario-based evaluations the tool facilitates the comparison of nickel-based options with MOZART-derived coatings intended to substitute HC. Results feature sustainability ratings, risk metrics and comparative analyses that assist stakeholders in making informed substitution choices consistent, with EU sustainability objectives.

The overall aim of the DST is to facilitate end users in defining SSbD-compliant alternatives, enabling rapid and economically feasible adoption by plating SMEs and large manufacturers.

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Developing a Tiered Safety Assessment Strategy for Safe and Sustainable by Design Applications

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online as oral presentation (without DOI)

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The Safe and Sustainable by Design (SSbD) framework supports the development of chemicals and materials by embedding safety and sustainability considerations throughout the innovation process. While the framework is applicable across sectors, its implementation in the plastics value chain remains limited. In this context, the Horizon Europe project ANALYST is developing a tiered and iterative SSbD assessment strategy aligned with technology readiness levels (TRLs), following the Joint Research Centre SSbD methodological guidance.

Across all assessment levels, the ANALYST approach starts with systematic data collection and curation, supported by natural language processing (NLP) tools to extract and organize existing information from diverse sources. Building on this foundation, the safety strategy is structured into three progressive levels addressing human and environmental health. At early innovation stages (TRL 1–3), where data are limited, the assessment relies on New Approach Methodologies (NAMs), with a strong emphasis on the use of *in silico* tools for hazard identification, and conservative exposure and risk considerations. At intermediate stages (TRL 4–6), *in vitro* NAMs and more advanced exposure models are integrated, enabling preliminary risk characterization. At later stages (TRL 7–9), the strategy supports comprehensive safety assessment in line with regulatory requirements, covering the full life cycle and value chain of plastic-based materials.

Beyond safety, the ANALYST framework integrates environmental, social, and economic dimensions within the SSbD concept, supported by a digital decision-support tool for multicriteria evaluation. The overall framework is being tested and validated through case studies in the plastics sector, to demonstrate how a tiered, NAM-based safety strategy can inform safer and more sustainable innovation pathways.

Development of Safe and Sustainable PFAS-Free Coatings: The BIO-SUSHY Approach

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online as oral presentation (without DOI)

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Per- and polyfluoroalkyl substances (PFAS) are widely used for their water and oil-repellent properties in various applications, including textiles, packaging, cookware, medical applications, electronics, etc. However, their persistence and toxicity present significant environmental and health challenges. The Horizon Europe BIO-SUSHY project aims to develop innovative coating solutions that align with the EU's chemical strategy for sustainability, targeting a toxic-free environment.

BIO-SUSHY's approach is built on three pillars: (i) research and innovation in hybrid organic/inorganic coating formulations, (ii) computational modelling to optimise performance and safety, and (iii) integration of the Safe and Sustainable by Design (SSbD) methodology. The developed solutions are validated in three strategic markets: textiles, food packaging, and cosmetic packaging.

Among the case studies, the application of sol-gel coatings to cosmetic glass containers demonstrates reduced waste (up to 25%), facilitates container reuse, and ensures user safety while meeting regulatory requirements. As part of its work on these coatings, BIO-SUSHY invests considerable efforts in implementing the Safe-and-Sustainable-by-Design (SSbD) framework, integrating sustainability strategies such as circularity and eco-design principles. Key to this approach is a multidisciplinary methodology based on computational tools and data-driven modelling, coupled with rapid release and

screening technology, all embedded within a life cycle thinking perspective. In this way, the principles of SSbD are applied to organic and hybrid coating formulations to ensure that, from an early stage of the innovation process, both safety concerns and sustainability criteria are addressed so that more safe and sustainable value chains can be established.

This presentation aims at providing an overview of the project concept, methodology and main outcomes in BIO-SUSHY case studies.

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Eco-Conscious Ni-Based Nanocomposites as Hard Chromium Alternatives: Chemistry, Equipment Upgrades, SSbD Process Engineering, and Innovation Assessment

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online (without DOI)

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The transition toward Safe and Sustainable by Design (SSbD) coating technologies is accelerating as industry seeks viable, REACH-compliant alternatives to hard chromium. This work presents an integrated approach combining green electrolyte design, equipment-level process innovation, and innovation assessment to advance nickel-based nanocomposite coatings as eco-conscious replacements for hard chromium. Building on developments from the MOZART project and complementary research at Creative Nano, boric-acid-free Ni electrolytes based on organic acids were formulated and reinforced with SiC, graphene, and WS_2 nanoparticles. These systems demonstrated stable dispersion behavior, enhanced nucleation, and significant improvements in mechanical and corrosion-resistant performance, with microhardness values exceeding 1100 HV and contact angles surpassing 120° under optimized conditions.

Beyond electrolyte chemistry, substantial engineering upgrades were implemented to enable reliable nanocomposite deposition at pilot scale. A 250-L dual-tank plating system was modified to incorporate controlled hydrodynamics, continuous electrolyte circulation, and a custom rotating rack for uniform current distribution. A high-power ultrasonication panel was integrated to promote nanoparticle deagglomeration and enhance mass transport, enabling both pre-treatment and periodic U/S activation during deposition. These modifications reduced porosity, improved particle incorporation, and strengthened crystallographic texture, particularly along the Ni(111) plane. Pilot-scale validation on forged steel piston rods confirmed uniform deposition, strong adhesion, and industrial applicability.

In parallel, SSbD principles guided waste minimization strategies, including the elimination of boric acid, reduced sludge formation, improved bath stability, and lower energy consumption through optimized current regimes. Real-time nanoparticle monitoring technologies further supported predictive bath management and process reproducibility.

Finally, an innovation assessment was conducted through targeted patent landscape analysis to evaluate freedom-to-operate, identify emerging trends in Ni-based nanocomposites, and position the developed technologies within the broader innovation ecosystem.

Overall, the combined advances in chemistry, equipment design, ultrasonication-assisted processing, and innovation assessment demonstrate a robust pathway toward sustainable, high-performance Ni-based nanocomposite coatings capable of replacing hard chromium in demanding engineering applications.

Enzyme-assisted pretreatment of PA12 for sustainable Plating on Plastics: Replacement of Cr^{6+} etching and Pd activation

sciforum-173349

online as poster presentation (without DOI)

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Plating on plastics (PoP) is broadly used in automotive, electronics, and household appliances to improve mechanical strength, corrosion protection, and surface aesthetics. Effective pretreatment of polymer surfaces is required to enable electroless deposition of a conductive Ni-P layer, which acts as the foundation for subsequent electroplating. However, established industrial processes depend on Cr^{6+}-based etching solutions and Pd-containing activators, raising serious environmental, health, and economic concerns due to the toxicity of Cr^{6+} and the high cost of Pd. Among polymeric materials, ABS and polyamides (e.g. PA6, PA66, PA12) are most frequently used in PoP applications.

In this study, chromic acid etching is replaced by an enzyme-based pretreatment using a protease (alcalase) and Pd-based activation is replaced by Ni salt-based activation which is more cost-effective. Alcalase is an alkaline serine protease capable of cleaving amide bonds and was therefore selected for the enzymatic pretreatment of PA12 surfaces, introducing polar functional groups that promote effective activation for subsequent electroless Ni-P deposition. The enzymatic pretreatment conditions were systematically optimized by varying the enzyme-containing solution temperature, enzyme concentration, and immersion time. Surface chemistry, morphology and adhesion were evaluated by FT-IR spectroscopy, water contact angle measurements, SEM/EDS and pull-off adhesion tests. The results showed the formation of uniform, thin and well-adhered Ni-P conductive layer on enzyme-treated PA12 substrates, highlighting the potential of protease-assisted pretreatment as a sustainable alternative for PoP.

Financial Evaluation of Advanced Gear Coatings

sciforum-166199

online as poster presentation (without DOI)

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In recent years there has been an active shift from conventional Hard Chromium plating to advanced protective coatings in the European plating industry. These coatings present suitable properties in order to be applied on gears improving their performance and complying with environmental standards. This study evaluates the financial feasibility of two emerging coating technologies utilizing SiC150 and Graphene through a detailed cost and cash flow analysis.

Firstly, unit costs were calculated for all stages of the coating process, including material, energy, equipment, labour, and overhead costs. For a standard gear, per-gear costs were determined for both SiC150 and Graphene coatings. When scaling up to batch production and considering the base gear costs, the analysis resulted in total production costs in which Graphene showed a slight cost advantage. Based on industrial-scale projections conducted at a later stage, the scalability and cost efficiency of both coatings were confirmed.

Finally, a cash flow analysis over ten years was calculated, incorporating expected sales growth, operating expenses, and an industrially relevant gross margin. Based on the analysis a positive cumulative cash flow is achieved from the early years, demonstrating strong long-term economic potential.

Hard Chromium plating remains lower in unit cost, however, the MOZART advanced coatings deliver non-financial benefits, such as enhanced wear resistance, extended service life, and reduced environmental and health risks. Between the two coating alternatives, Graphene coatings provide a small cost advantage.

This analysis targets to evaluate the adoption of SiC150 and Graphene coatings in industrial gear manufacturing supporting informed decision-making for manufacturers who need sustainable and high-performance coating solutions.

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Making nano-enabled coatings safe and sustainable by design: opportunities and challenges

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online (without DOI)

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Nano-enabled coatings have emerged as advanced solutions for diverse coating applications. By manipulating materials at the nanoscale, these coatings provide enhanced properties, e.g. durability, corrosion resistance, self-cleaning, hydrophobicity or antimicrobial activity to metals, glass, ceramics, and textiles. Not only they offer advanced performance but also act as substitutes to traditional coatings linked to toxicity, such as hard chromium. However, they also must be shown to be safe alternatives, in order to avoid regrettable substitutions.

Originating from the EU's Chemicals Strategy for Sustainability, the Safe and Sustainable by Design (SSbD) concept aims to offer a novel approach in guiding innovation away from harmful substances towards sustainable, competitive alternatives. The EU has been working on an actionable framework to facilitate the process. The SSbD framework is still under development, but has already offered opportunities, and challenges to European researchers, industry and regulators.

In my presentation, I will be giving examples of research focussing on performance and properties of nano-enabled coatings along with data on their behaviour, both as pristine, as well as aged, in scenarios that simulate their life cycle. I will be emphasising that understanding fundamental behaviour at the nanoscale, offers new tools to predict coating behaviour, toxicity and sustainability in tandem, supporting, facilitating and streamlining the SSbD approach.

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PFAS-Free Coatings: Capturing a €1.8 Billion Market Opportunity

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The BIO-SUSHY project is developing PFAS-free, bio-based coatings that potentially address a portion of the expanding EUR 1.5 billion PFAS-free coatings market and significant environmental challenges. Companies that adopt PFAS-free coatings mitigate compliance risks, expand their market presence, and enhance their brand reputation. On the other hand, companies that persist in using PFAS face potential fines and restricted market access due to increasingly stringent regulations.

BIO-SUSHY coatings are aligned with evolving regulatory requirements and increasing consumer demand for sustainable products. In fact, the project implements Safe-and-Sustainable-by-Design (SSbD) principles, initially demonstrating applications for textiles, paper food trays, and cosmetic glass packaging, with potential for broader industry adoption. The PFAS-free coatings market is forecasted to grow from EUR 1.5 billion in 2024 to EUR 2.1 billion by 2030. Key markets include Europe (35-40% share, led by REACH), North America (with state-level PFAS bans), and Asia-Pacific (the fastest-growing region, accounting for 40% of the food packaging market).

The main BIO-SUSHY innovative coatings are thermoplastic powder coatings (80-98% bio-based) for food packaging, where regulatory bans in the EU and US, as well as corporate commitments from quick-service restaurants (QSR), are increasing demand. Hybrid organic and inorganic sol-gel coatings (23-46% and 5-15% bio-based, respectively) are developed for technical textiles and glass cosmetic packaging.

Key success factors include demonstration at Technology Readiness Level 6 (TRL6), intellectual property rights (IPR) protection, comprehensive SSbD documentation, and a standardization roadmap that lowers market entry barriers, positioning SSbD-validated coatings as preferred alternatives in markets where regulations are phasing out persistent pollutants.

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PFAs-Free surface finishing in the automotive sector: A comprehensive mapping of approaches for safety, sustainability, and functionality

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Per- and polyfluoroalkyl substances (PFAs) have traditionally been used in automotive surface finishing applications due to their exceptional functional performance, particularly in the corrosion protection of metallic surfaces and in imparting easy-to-clean properties to plastics and glass. Increasing evidence of their environmental persistence, long-range transport potential and potential human and occupational health effects has intensified regulatory action and driven the search for safer alternatives. This ranges from existing REACH restrictions on specific PFAs, including PFOs, PFOA and long-chain PFCAs, all of which belong to the PFAs class, to the ongoing broad PFAs restriction proposal.

Although OECD assessments indicate that PFAs-free coatings are commercially available, substantial gaps remain in understanding their hazard profiles, long-term stability, processability, and sustainability within automotive manufacturing. These information gaps hinder informed substitution and increase the risk of regrettable substitution.

The revised Safe and Sustainable by Design (SSbD) framework developed by the European Commission's Joint Research Centre (JRC) provides a structured approach to integrating design and re-design, safety, sustainability, and functional performance in material and process development. However, explicit application of SSbD framework to PFAs-free coatings, particularly within the automotive coatings processes, remains limited in the literature.

This work provides a comprehensive overview of the current state of the art in PFAs-free alternatives for automotive surface finishing, with particular emphasis on methodologies (e.g., formulation strategies, application methods, and curing processes) that impact safety, sustainability, and technical performance, thereby influencing the feasibility of substitution. Existing literature and European initiatives were analysed to identify methodologies and strategies for the development and characterisation of PFAs-free alternatives, highlighting how these dimensions are addressed individually or in combination. Special attention is given to anti-corrosion coatings for metal substrates and easy-to-clean finishes for plastic and glass components, which represent high-impact applications where performance, safety, and sustainability intersect.

By mapping existing approaches and identifying knowledge gaps, this review aims to support future research and industrial development towards the design of safe, sustainable, and technically effective PFAs-free coatings. The findings underscore the need for holistic SSbD approaches that explicitly incorporate process-level considerations into the design and evaluation of next-generation automotive coatings.

Phasing out Critical metals in Membrane Fuel Cells: Evaluating the environmental impact and risk of Pt substitution towards optimized cathode performance

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online as oral presentation (without DOI)

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Platinum (Pt) has unique chemical and catalytic properties, making it indispensable for several key industrial applications, such as Renewable Energy or Electric Mobility. However, due to its high price and scarcity, reliance on import from sources outside Europe, and lack of effective substitutes for Pt, it is categorized as a Critical Raw Material (CRM). To address this, several attempts have been made to (partially) replace Pt with more inexpensive and abundant metals, such as Iron, Molybdenum or Cobalt. Nevertheless, prevous reports on Pt substitution often focus only on the catalyst's properties during optimization at the laboratory scale, while criteria of Safety and Sustainability are often overlooked.

According to the Safe and Sustainable by Design (SSbD) framework, safety and sustainability considerations should be integrated into the early stages of development for new materials, by iteratively applying the assessment phase and the re-design phase of the framework at each scale of development. Specific operations or substances can be identified as hotspots during the assessment phase at early stages of development, and targeted for substitution / minimization during the re-design phase, before technology lock-ins occur.

Previous sustainability assessments have revealed that the Pt catalyst in Membrane Fuel Cells (MFCs) is a major contributor to the environmental impacts. Here, the (partial) substitution of Pt by Nickel-based coatings is addressed, as a cathode catalyst for MFC applications. Core-shell nanoparticles are prepared with a range of Pt loadings between 0.01-0.2 mg/cm^2 and tested as catalysts for oxygen reduction reaction in acidic conditions typical for MFC. A comparative Life Cycle Assessment (LCA) and Chemical Risk Assessment (CRA) of different catalyst compositions with varying Pt content is performed, to establish a correlation between the catalyst performance, safety and sustainability criteria, and quantify the trade-off between the catalyst performance and sustainability when increasing Pt loading. The outcomes of the assessments are used to select an optimal Pt content for upscaling and characterization at the demonstrator scale. Finally, the outcomes are used to establish Re-Design indicators and SSbD Criteria for CRM substitution, which can contribute to SSbD assessments on MFC applications beyond the pilot scale.

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Self-Activating Sprayable Resins for Sustainable Plating on Plastics

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online as oral presentation (without DOI)

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Plating on plastics (PoP) is a crucial process in current industrial practice. Indeed, PoP combines the advantages of polymers (low weight, reduced cost and flexibility) with those typical of metals (aesthetic appearance, wear resistance, high electrical or thermal conductivity and ferromagnetic behavior). For these reasons, PoP finds widespread use across numerous sectors, including the automotive industry, electronics, household goods manufacturing and fashion.

State-of-the-art PoP processes applied to ABS (the most commonly employed polymer), or to other plastic substrates, typically rely on materials that are either hazardous or limited in availability. In particular, the surface etching step necessary to improve metal–polymer adhesion typically involves highly toxic hexavalent chromium compounds. Furthermore, the activation step conventionally requires palladium, a scarce element classified by the European Union as a critical raw material.

Within the framework of the safe-and-sustainable-by-design (SSbD) strategy, the European FreeMe project seeks to remove both Cr(VI) and Pd from the PoP process, ensuring compliance with REACH regulations. In this context, the present study reports on the development of sprayable resin formulations containing appropriate metallic precursors. Owing to the incorporation of these precursors, the materials exhibit self-activating behavior, thereby eliminating the need for conventional etching and activation steps. The embedded precursor is subsequently reduced to its metallic form through immersion in a reducing solution, generating metallic nuclei that initiate the electroless deposition of NiP.

In addition to NiP, copper coatings can also be deposited via electroless plating using a similar approach, as demonstrated by selecting an appropriate metal precursor within the resin and a suitable plating bath. The resulting NiP and Cu layers are thoroughly characterized to assess their uniformity, morphology, phase composition, and adhesion. The resins described in the present study can be directly spray-coated onto ABS substrates, resulting in easy potential industrial implementation.

SSbD assessment for High Entropy Alloy Coatings

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online as oral presentation (without DOI)

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Recent advances in materials science have accelerated the development of high-entropy alloys (HEAs), a class of multicomponent materials recognized for their enhanced properties, structural stability, high-temperature resistance, and oxidation tolerance, enabling applications, such as aviation turbine engine hot-section components and other high-temperature environments. To ensure that innovations align with safety, sustainability and socio-economic targets, the European Union's (EU) Safe-and-Sustainable-by-Design (SSbD) framework provides a methodology for evaluating chemicals, materials, and products early in their design and throughout their entire life cycle. The methodology consists of five hierarchical steps, applied in an iterative way, aiming for continuous improvement across EU target pillars.

The EU-funded M2DESCO project aims to develop HEA-based coatings deposited via Physical Vapor Deposition (PVD), free from hazardous substances and with reduced reliance on critical raw materials for industrial tooling applications (e.g., hot-stamping tools). Central to this effort is the implementation of the SSbD framework to support a comprehensive evaluation of safety and sustainability aspects of the developed coatings. In the present work, a scoping analysis is performed to establish the objectives of the evaluation, including system boundaries, (re-)design actions, and relevant indicators that will guide the SSbD assessment. A simplified SSbD assessment follows, reflecting the project's current maturity level across the coatings' developed life-cycle stages. The current focus on safety assessment includes hazard classification for the metallic elements that comprise the HEA coatings, occupational exposure during the manufacturing of the HEA targets and the PVD coating process, as well as exposure during the use-phase of the coated hot-stamping tools. Results will focus on materials' toxicity evaluation based on current OECD guidelines and relevant ISO standards and quantitative exposure assessment for the production and the application phase evaluating human and environmental safety aspects via the use of *in silico* tools and established databases, such as European Chemicals Agency (ECHA). Sustainability evaluation follows through Life Cycle Assessment, presenting preliminary identifications of potential environmental hotspots in the early design phase. The goal of the present work is to showcase the progress made in the implementation of the SSbD framework for the production of novel HEA coatings, while highlighting methodological limitations that need to be addressed to strengthen the integration of safety and sustainability principles within the broader materials industry.

Tailoring the SSbD Approach to surface treatment processes: a streamlined framework for sustainability and safety

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online as poster presentation (without DOI)

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The Safe and Sustainable by Design (SSbD) framework offers a solid foundation for comparing the risks and impacts of products and processes. Although it is currently focused on the chemical and material sectors, its principles are highly relevant and could be extended to other industrial fields. In these broader contexts, SSbD can guide the (re)design of products and production systems towards safer and more sustainable outcomes.

The Surfera Plus Network of Excellence is a Spanish project funded by the CDTI (Center for Technological Development and Innovation) through the CERVERA 2023 Program. Its objective is to establish a Network of Excellence to valorize surface functionalization technologies for national, strategic, and socially impactful industrial sectors. The network comprises the national technology centres AIN (Coordinator), TEKNIKER, CIDETEC, IDONEAL, and CTME.

Within this framework, CTME adapted the SSbD methodological guidance originally developed by Abbate et al. for chemicals and materials to the surface treatment sector. This adaptation establishes a design framework that emphasizes sustainability and occupational safety while providing a flexible and adaptive methodology that enables efficient SSbD implementation. The original guidance served as the starting point for developing the adapted methodology. Its capabilities and outcomes were evaluated through two demonstrators developed within the Surfera Plus project, allowing the identification of critical areas requiring intensified efforts or methodological adjustments. In addition, a method to assess socioeconomic impacts was developed, incorporating life cycle cost analysis, critical materials assessment, and social Life Cycle Assessment (social LCA).

The resulting methodology, based on Abbate et al.'s work, includes the identification of critical points, more concise approaches for specific steps, and a social assessment tailored to the surface treatment sector. Except for the LCA step, specific methodologies were developed for all stages, streamlining SSbD application in this field. In line with Abbate et al.'s recommendations, the current approach considers only the intrinsic risks of materials; future developments could incorporate risks associated with individual unit processes.

Tiered Hazard Assessment Implementing New Approach Methodologies for PFAS-Free Coatings in a Safe and Sustainable by Design Context

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online as poster presentation (without DOI)

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Poly- and perfluoroalkyl substances (PFAS) are widely used in industrial applications due to their functional properties; however, concerns related to their persistence and potential adverse health effects are driving regulatory restrictions and the need for safer alternatives. In response, the PROPLANET project aimed to develop PFAS-free coating solutions within the Safe and Sustainable by Design (SSbD) framework, integrating human health hazard assessment throughout the innovation process.

In PROPLANET, hazard assessment was implemented using a tiered approach across the coating development stages. Initially, existing toxicological information on individual coating components was collected through data mining of safety data sheets and regulatory databases, maily ECHA CHEM, to support the selection of safer substances and identify data gaps. Where relevant information was missing, New Approach Methodologies (NAMs) were applied to address data gaps and support early hazard profiling. In particular, *in silico* models were developed and applied to assess the mutagenicity of PFAS-free alternatives.

Building on this early screening, *in vitro* NAMs formed the core of the hazard assessment strategy for candidate coating formulations. A structured battery of assays, informed by Adverse Outcome Pathways, was applied to investigate key toxicological endpoints, including cytotoxicity, genotoxicity, inflammatory responses, carcinogenic potential, endocrine activity, and reproductive toxicity. Whenever possible, PFAS-free formulations were tested in parallel with PFAS-based benchmark coatings.

The outcomes of the hazard assessment informed coating development and supported the identification of candidates with lower hazard potential for further advancement. Overall, *in vitro* results indicated limited adverse effects for most

PFAS-free alternatives compared to PFAS-based benchmarks, although some formulation-specific responses were observed and warrant further investigation. By embedding a tiered, NAM-based hazard assessment within the SSbD framework, PROPLANET supports the development of safer PFAS-free coatings and contributes to the advancement and acceptance of NAMs.

Data collection and organization to support decision making process in material selection

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online as poster presentation (without DOI)

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The transition toward advanced and sustainable materials is increasingly challenged by the volatility of raw material supply chains, particularly in the European context, where a strong dependence on critical raw materials requires rapid adaptation in material design and selection. In this scenario, decision-making tools play a crucial role in enabling timely responses to changes in availability, cost, and environmental impact, while maintaining required performance levels.

This contribution presents an integrated Life Cycle Performance Analysis (LCPA) approach embedded within a Sustainable Decision Support System to support material selection and, where relevant, process optimisation. The methodology goes beyond conventional life cycle assessment by coupling environmental indicators with performance-related metrics, enabling a balanced evaluation of functional efficiency, durability, and sustainability across the entire life cycle of a material solution. The approach facilitates systematic comparison of alternative material compositions and processing routes, while explicitly addressing trade-offs between technical performance, resource efficiency, and environmental footprint.

The resulting decision support system enables multi-criteria analysis that jointly considers performance targets, sustainability objectives, and supply-chain constraints. By organising information in a flexible and modular structure, the system supports rapid re-evaluation of material solutions when boundary conditions evolve, such as reduced availability of specific alloying elements or the need to prioritise lower-impact or locally sourced raw materials.

Flexible Manufacturing approach of High-Entropy and compositionally complex CerMet Feedstock for Thermal Spray Applications

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online as oral presentation (without DOI)

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High-Entropy Alloys and compositionally complex CerMet systems are opening access to an unprecedented materials design space, offering significant potential for tailoring mechanical, functional, and environmental performance. This expansion has been strongly enabled by advances in computational power, which now allow extensive modelling and simulation campaigns to explore large compositional domains. However, translating these virtual material concepts into reliable, experimentally validated solutions remains a major challenge, particularly when data at an industrially relevant scale are required.

A critical bottleneck lies in the availability of suitable feedstock for thermal spray processes, where compositional complexity, phase stability, and powder quality must be controlled simultaneously. Many synthesis routes struggle to deliver powders beyond laboratory scale or to achieve sufficiently low variability at pilot or industrial scale, thereby limiting the validation of modelling predictions under realistic processing conditions.

This contribution presents the solid-state mechanical alloying approach developed by MBN to address this challenge. The flexibility of mechanical alloying enables the synthesis of complex alloy systems without melting, allowing the combination of elements with widely different thermophysical properties while maintaining compositional homogeneity. The intrinsic scalability of the process supports the transition from laboratory batches to pilot-scale production, providing feedstock quantities compatible with industrial thermal spray trials.

For CerMet systems, the ceramic reinforcement phase is formed directly within the metallic matrix through a carbothermic reaction activated during mechanical alloying, resulting in a fine and well-dispersed microstructure suitable for coating deposition. The resulting powders can be tailored in terms of particle size distribution and morphology to meet the requirements of different thermal spray technologies.

The presented approach demonstrates how solid-state feedstock manufacturing acts as a key enabler for bridging computational materials design and experimental validation, supporting the exploration of complex material systems under realistic industrial conditions.

MAX phase ceramic coatings fabricated by aerosol cold spray

sciforum-167739

online as oral presentation (without DOI)

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MAX phases are a promising material group for high-temperature coating applications. Currently, the search for sustainable MAX phase synthesis and coating techniques suitable for this particular material group is still ongoing. One of the most promising method is cold spray, which prevents the thermally-induced phase changes of the coating material during deposition, while drastically reducing the energy and gas required for the process in comparison to other thermal spraying techniques. In this work, a modified low pressure cold spray (LPCS) system – aerosol cold spray (ACS) has been successfully used to fabricate Ti_2AlC, Cr_2AlC and Ti_3AlC_2 coatings on carbon steel substrate. Structural and microstructural analysis indicated successful deposition of dense and crack-free coating without inducing phase changes during the spraying process using compressed air as process gas. Additionally, post-processing of the coatings by free- and spark plasma sintering methods were tested. The analysis of post-processed coating's microstructure indicated the increase of interparticle bonding within the coating, however free sintering method resulted in cracking within Ti_3AlC_2 coating, and formation of porosity in Cr_2AlC coating, due to intense diffusion of aluminum towards the carbon steel substrate. This work presents the first successful deposition of MAX phase coatings using a LPCS-based technique, as well as post-processing and characterization of their structural and mechanical properties.

Using thermal deposition for ballistic protection plates of bulletproof vests

sciforum-167673

online as poster presentation (without DOI)

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The present study focuses on enhancing ballistic protection, a critical factor in the performance and reliability of modern military equipment. Improving ballistic resistance is essential to ensure the personal safety of military personnel, particularly through optimizing protective vests. In this work, thermal spraying using a plasma jet was performed on Armox ballistic steel substrates, employing both metallic and ceramic powders as feedstock. The coated samples, prepared to predetermined dimensions, were subjected to extensive evaluation of their mechanical and microstructural properties to characterize their behavior in relation to ballistic protection efficiency. Investigations conducted by optical and scanning electron microscopy (SEM) enabled detailed assessments of coating adhesion to the substrate, as well as analyses of the coating morphology, thickness uniformity, and porosity. The interface between the deposited layer and the base material was also examined. To assess the potential of the coatings, tribological tests, including microscratch and microindentation analyses, were performed. The study provides a comparative assessment of the performance of metallic and ceramic coatings, aiming to evaluate the applicability of thermal spray deposits for improving the ballistic resistance of armor plates integrated into individual (body) military protection systems.

Annealing of Diamond-Coated Tools: A Flexible Approach to Enhancing interfacial Fatigue strength and Milling Performance

sciforum-167467

online as oral presentation (without DOI)

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Diamond coatings deposited on cemented carbide tools are extensively employed in the machining of non-ferrous materials, including aluminum alloys and composites. A key issue for ensuring a sufficient diamond-coated tool life, especially in milling, is the fatigue strength of diamond coating-substrate interface. Nano-crystalline diamond (NCD) coatings deposited on cemented carbide tools are characterized by high residual stresses. The high level of residual stresses in the diamond film structure are attributed to epitaxial and thermal expansion coefficients mismatch of the diamond coating and its cemented-carbide substrate. Thus, the potential for reducing residual stresses in diamond films deposited on cemented carbide inserts, with the aim of improving their effective interfacial fatigue strength and wear resistance, is of high importance.

NCD coatings were deposited on cemented carbide inserts, and a subset of the coated tools was subsequently annealed under vacuum to decrease residual stresses within the film. Inclined impact tests at ambient temperature were performed on both as-deposited and annealed diamond-coated tools to evaluate their effective interfacial fatigue strength. Depending on the applied impact load, damage initiated at the film–substrate interface after a certain number of impacts, leading to coating detachment and lifting. Residual stresses within the diamond films were quantified through finite element method (FEM) analysis of the impact imprints. In addition, milling experiments were conducted using aluminum foam as the workpiece material to assess the cutting performance of the coated tools. A clear correlation was identified between the interfacial fatigue strength of the diamond coatings and their residual stress state as influenced by annealing. The obtained results show that an impressive enhancement of the effective interfacial fatigue strength and milling performance of diamond-coated tools can be achieved by decreasing the structural residual stresses via appropriate adjustment of the annealing duration and temperature.

Catalyst selection and polymerization optimization of biobased poly(butylene succinate) for sustainable applications

sciforum-170103

online (without DOI)

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Poly(butylene succinate) (PBS) is a biobased and biodegradable polyester with strong potential as a sustainable coating binder. However, its application in coatings requires prcise control over molecular weight, crystallinity, thermal transitions, mechanical integrity, and biodegradoin behavior. These properties are directly governed by polycondensation kinetics, which are highly sensitive to catalyst selection and reaction conditions. This study investigates the catalytic synthesis and optimization of PBS from biobased succinic acid and 1,4-butanediol, focusing on catalyst-driven structure-property relationships relevant to coating performance. Specifically, titanium butoxide, titanium isopropoxide, and antimony trioxide were utilized as polycondensation catalysts and systematically compared. The effect of catalyst type on chain growth, crystallization behavior, and degradation phenomena were examined. PBS samples were collected at defined intervals during the polycondensation step to monitor polymer evolution. Fourier transform infrared spectroscopy (FTIR) was used to track ester bond formation, X-ray diffraction (XRD) to assess crystalline structure, and differential scanning calorimetry (DSC) to evaluate melting and crystallization behavior. Enzymatic hydrolysis provided insight into structure-biodegradability relationships, while tensile testing correlated molecular architecture with mechanical performance. Distinct catalytic behaviors were observed, with titanium-based catalysts promoting faster polycondensation and antimony trioxide offering improved control over molecular weight development. Optimized PBS materials demonstrated a favorable combination of thermal stability, mechanical performance, and controlled biodegradation, supporting their applicability in sustainable coating systems.

Deposition temperature effect on properties of electrosprayed ZnO thin films

sciforum-164341

online as poster presentation (without DOI)

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Zinc oxide (ZnO) thin films are the subject of extensive investigation because of their outstanding physical characteristics that make ZnO thin films highly suitable for a broad range of applications such as optoelectronic systems, transparent electronic devices, gas sensing technologies, solar energy conversion, and biosensing platforms.

The performance of ZnO-based thin films is closely influenced by the selected deposition methods and the specific conditions under which the films are grown. Various methods have been developed for the deposition of ZnO thin films, among which electrospray has emerged as a versatile and scalable technique that enables tunable film properties through straightforward variation of deposition parameters. One particularly important parameter is the substrate temperature, which governs droplet mobility on the substrate surface and significantly influences film morphology and crystallinity.

In the present study, ZnO thin films were deposited by electrospraying at relatively low substrate temperatures ranging from 120 °C to 150 °C. The surface morphology, roughness, crystallinity, water contact angle, and film thickness were systematically investigated, and their dependence on substrate temperature was analyzed. The potential application of the films as ammonia gas sensors was evaluated using the quartz crystal microbalance (QCM) method, for which the films were deposited onto quartz crystal resonators and their frequency responses were monitored during ammonia exposure.

The results demonstrate that the properties of ZnO thin films can be effectively tuned by adjusting the substrate temperature, enabling optimization for gas-sensing applications.

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Design of Hygro-Swelling Polymer Films Exhibiting Thickness-Based Color Shifts

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Thin-film hydrophilic polymer coatings represent an effective platform for the development of optical humidity sensors based on color changes. Hydrophilic polymers absorb water molecules from the environment, which leads to spontaneous swelling and a proportional increase in the thickness of the film. When film is deposited on reflective substrate even small changes (a few nanometers) in thickness are sufficient to shift the reflectance spectrum and cause a distinct change in the perceived color. This allows visual and contactless detection of humidity with high sensitivity, the process being fully reversible upon drying. Combined with the ease of fabrication, low cost, and the possibility of chemical tuning, thin-film hydrophilic polymers represent a promising material for integration into next-generation humidity optical sensor platforms.

A new hygrosensitive poly(vinyl alcohol) derivatives comprising grafted poly(N,N-dimethylacrylamide) chains of varied length and graft density were developed recently and has been shown to be a promising materials for humidity detection. The influence of the grafting density and chain length on the sensing properties for two copolymers annealed at three different temperatures (60◦C, 120◦C and 180◦C) was systematically studied. Polymer films deposited by spin-coating method with a thickness of 140-200 nm were investigated spectrophotometrically and the optical constants (refractive index and extinction coefficient) were determined. When exposed to humidity in the range of 5-95% RH the films demonstrated a relative change in thickness between 50% and 100%, as well as a change in the refractive index. It has been shown that hysteresis is influenced by both - the annealing temperature and the structure of the copolymer. The moisture absorbed in the films at 95% RH humidity was evaluated by using the quartz microbalance method. Both structural variations and annealing temperature were found to have an impact on copolymers' optical and sensing properties.

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Effect of Mo, W and Cr over the mechanical properties of clean and sustainable magnetron sputtered AlTiN layers

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This study investigates the microstructure and the mechanical performance of Mo, W and Cr doped AlTiN coatings. The coatings have been produced by magnetron sputtering, a waste-free thin film production technology. It will be discussed whether the Mo and W containing AlTiN based coatings could be qualified as medium/high-entropy nitrides as the dominant phase is a solid solution. In this frame, the research is part of the Horizon Europe project M2DESCO (grant agreement 101138397), aimed to develop novel computational models for the design of safe & sustainable high-entropy coatings. The ultimate goal is to achieve coatings which allow the lifespan_enhancement of machining tools by 50%, which would substantially reduce the consumption of raw materials used in these items.

The coatings have been deposited on high-speed steel AISI-M2 (60 HRC) by co-sputtering a $Al_{33}Ti_{67}$ target in DC_pulsed mode with a Mo or a dual-tile Mo/W or Mo/Cr target in HIPIMS mode, thus obtaining TiAlMoN, TiAlMoWN and TiAlMoCrN coatings respectively. The coating series presented in this study were prepared for different HIPIMS power, while keeping constant the DC sputtering power over the AlTi target. In addition, the influence of the N_2 mass flow has also been investigated. The adhesion of the films was optimized with a combination of Ti and TiN cladding layers.

The effect of the Mo, Mo/W and Mo/Cr co-sputtering, and the N_2 mass flow significantly affects the structure and hardness of the coatings. The dominant face-center-cubic (FCC) structure of the Mo-free AlTiN is also affected upon the increase of the Mo, Mo/W and Mo/Cr sputtering powers, as reflected in notable changes in the crystallite domain sizes and the cell lattice parameters, while the indentation hardness of the coatings notably increases. In addition, the sputtering of dual-tile Mo/W target leads to even higher hardnesses over these of the TiAlMoN coatings.

Electrodeposited low-Pt core–shell nanoparticles as oxygen reduction electrocatalysts for PEMFCs

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Over the past two decades, polymer electrolyte membrane fuel cells (PEMFCs) have made remarkable progress in performance and durability; however, the high cost associated with platinum-based cathodes remains a major barrier to large-scale deployment. In this context, the development of scalable, platinum-efficient oxygen reduction reaction (ORR) electrocatalysts is a critical challenge.

In this work, a scalable electrodeposition approach for the fabrication of nanostructured core–shell (Ni-W)@Pt electrocatalysts with ultra-low platinum loading for PEMFC cathodes is presented. Using pulse electrodeposition, Pt shells were directly deposited onto non-noble Ni-W cores, enabling precise control over nucleation, particle size, surface coverage, and shell morphology while grown directly on the gas diffusion layer. Platinum loadings as low as 0.013 mg cm^{-2} were achieved while maintaining homogeneous catalyst distribution.

The catalysts were comprehensively characterized by means of FE-SEM, HR-TEM, and ICP-MS, and their ORR activity was evaluated in acidic media. The optimized (Ni-W)@Pt catalysts exhibited high open-circuit potentials (≥ 0.95–1.0 V vs. RHE) and outstanding mass activities, reaching ~10 A g^{-1} at 0.9 V, despite the drastically reduced precious metal content. Complementary machine-learned force field simulations provided insight into strain effects arising from the Ni-W core on the Pt shell, supporting the experimentally observed activity performance. Additionally, the influence of Pt loading and mesoporous shell structures on electrode durability is investigated.

The results demonstrate that electrodeposition is an industrially relevant and versatile strategy for producing high-performance, low-Pt PEMFC cathodes, offering a promising pathway toward cost-effective and sustainable fuel cell technologies.

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Environmental pH Effects on the Stability of Sustainable Pickering Emulsions for Edible Coating Applications

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The development of safe and sustainable coatings derived from food by-products represents an important strategy within circular bioeconomy frameworks. In this study, high internal phase Pickering emulsions (HIPEs) were developed using ultrasound-modified high-methoxyl pectin extracted from citrus processing waste combined with commercial zein from maize. The resulting polysaccharide–protein complexes were investigated as stabilizing particles for oil-in-water emulsions intended for edible coating applications on fresh-cut pineapple. Pectin (2.0% w/v) was extracted from citrus fresh-produce waste and structurally modified using high-power ultrasound. The modified pectin was subsequently combined with increasing concentrations of zein (0.0–2.0% w/v) to form pectin–zein complexes that stabilized emulsions with a fixed oil fraction ($\phi = 0.6$). The influence of environmental pH on emulsion stability was evaluated by measuring droplet size distribution and ζ-potential at pH 4, 7, and 10 using electrophoretic light scattering (Zetasizer Nano, Malvern Instruments Ltd., UK). Results demonstrated a strong pH-dependent stability of the Pickering emulsions. The smallest droplet sizes were observed at pH 4, where positively charged zein interacts electrostatically with negatively charged pectin, promoting the formation of strong interfacial complexes and enhanced emulsion stability. Near neutral pH (≈7), close to the isoelectric point of zein (pI ≈ 6.2–6.8), electrostatic interactions weakened due to partial charge neutralization, resulting in increased droplet growth, aggregation, and reduced stability. Under alkaline conditions (pH 10), both pectin and zein carried negative charges, leading to electrostatic repulsion and a renewed decrease in droplet size. At this pH, stability was primarily governed by repulsive forces, as confirmed by the more negative ζ-potential values, although interfacial cohesion between biopolymers was reduced compared with acidic conditions. Overall, the findings highlight the critical role of environmental conditions, as the pH, in modulating polysaccharide–protein interactions and the stability of pectin–zein Pickering emulsions. These results support the potential of ultrasound-modified citrus pectin and zein as sustainable stabilizing particles for the design of circular edible coatings and thin films based on high internal phase emulsions.

Formation and oxidation studies of Thermal Barrier Coatings with Polymer Derived Ceramic Bond Coats on TiAl alloys

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Monocrystalline Ni-based superalloys are the current state-of-the-art materials for blades in jet turbine engines . They are coated with thermal barrier coatings (TBCs) including outer layer (top coat) and inner layer (bond coat) for application in the hot section . The former is made of zirconium oxide stabilised with yttrium oxide (YSZ) with a thickness of 100-300 µm, whereas the latter is based on either metallic MCrAlY (M=metal) interlayer or diffusion aluminide layer with a thickness of approx. 80 µm. TiAl alloys, due to a much lower density than Ni-based super alloys (3.7-3.9 vs. 8.0-8.7 g/cm^3) stand out as a very interesting alternative for the lower temperature section of the jet engine. What is more, application of a TBC could allow the use of TiAl turbine blades at higher temperatures. But, when TBCs and TiAl alloys are combined, brittle phases are formed at the with the bonding layer (MCrAlY).

The main aim of this work, is to address aforementioned problem with the application of TBCs on the Ti48Al2Cr2Nb (4822) alloy with a bond coat based on polymer-derived ceramic (PDCs) coatings from the SiAlOC system. In [1], SiAlOC coatings were already shown to improve the corrosion resistance of 4822 alloy. TBCs based on YSZ were obtained at several different temperatures (830, 850, 900 and 950°C) using an EB-PVD process. Microstructural studies (SEM and EDS) along with advanced structural studies (Raman confocal imaging) revealed that the application of the hollow cathode (HC) plasma in the EB-PVD process enabled the successful formation of columnar ceramic coatings at temperatures up to 200°C lower than typical, while still meeting most of the requirements for TBC applications. The coated and bare TiAl specimens were oxidized in lab air for up to 800 h at 750 °C, the current application limit, and 900 °C, the future application aim. Further cross-sectional analysis was done to study the impact of oxidation and the overall adhesion of the coatings.

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Functional thin films from ultrasound-modified waste-derived pectin for coating applications

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Thin film technologies based on renewable sources, as agri-food residues, are attracting increasing interest as sustainable, high-performance materials for advanced coating applications, such as preservation systems for the postharvest industry. This work explored the ultrasound-assisted functionalization of citrus waste pectin as a bio-based material for coating applications. Pectin extracted from orange peel and pomace residues was modified using pulsed high-power ultrasound (2–5 min), and its performance was compared with untreated and commercial pectin references. Ultrasound treatment induced controlled molecular rearrangements, increasing esterification degree and methoxyl content, so converting citrus pectin into a high-methoxyl form without significant degradation. In addition to a 50~60% increase in its antioxidant performance. Uniform modified pectin-based thin films were fabricated by casting, with thicknesses of 50 - 63 µm. The optimized film formulation (F-HPU-MCP-2) exhibited enhanced properties, including a 70% increase in elongation at break, an improved surface barrier with 60% higher WCA, 45% reduction in water solubility, and a complete ultraviolet light shielding. The coating performance was assessed by applying the optimized film-forming solution as edible coatings on fresh strawberries (cold storage). The coating effectively reduced moisture loss in 15~30%, delayed fungal growth, preserved fruit integrity/firmness and colour, extending strawberries shelf-life for up 10 days. These findings demonstrate high-power ultrasound as an efficient green route for tuning the physicochemical and functional properties of waste-derived biopolymers for development of sustainable thin films/coating systems with enhanced functionality.

Harnessing the Air-Water Interface: A Scalable Platform for Bio-inspired Polydopamine Thin Films in Multiple Applications

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Polydopamine (PDA) has emerged as a uniquely versatile, biomimetic polymer with profound implications for environmental, biomedical, and energy applications. However, traditional substrate-dependent deposition methods often obscure its intrinsic supramolecular ordering and limit the fabrication of free-standing architectures. This talk highlights recent breakthroughs in harnessing the air-water interface for the bottom-up synthesis of highly oriented, nanometric PDA thin films. By carefully controlling intermolecular interactions at the gas-liquid boundary, we demonstrate the formation of PDA films with a unique 2D-like layered structure, driven by ordered eumelanin-like protomolecule stacking.

Crucially, this interfacial self-assembly enables extraordinary physical properties that surpass those of conventional PDA coatings. Nanoindentation studies reveal superior mechanical resilience in these films—exhibiting a Young's modulus of 13 ± 4 GPa and a hardness of 0.21 ± 0.03 GPa—allowing these ultrathin layers to be easily transferred to diverse substrates or utilised as robust, free-standing membranes. Furthermore, we will explore the multi-responsive nature of these polycatecholamine nanomembranes, showcasing their capacity for rapid, reversible mechanical actuation triggered by light irradiation, thermal variations, and atmospheric moisture.

The combination of exceptional mechanical robustness, tunable supramolecular ordering, and stimulus-responsiveness establishes air-water interface-derived PDA thin films as a highly scalable and versatile platform. By connecting fundamental structural analysis with practical utility, this presentation will outline how these free-standing films can be integrated into next-generation technologies, with a focus on advanced electrochemical sensors, energy harvesting, actuators and more.

Modification of Diamond-Like Carbon (DLC) to improve specific tribological characteristics for automotive steel components

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Carbon-based materials play an important role in today's science and technology. Carbon is a very versatile element whose two most interesting allotropic forms are Diamond (sp3) and Graphite (sp2). This way, the DLC has consolidated all its applications in the automotive and mechanical sectors in general. The management of the sp3/sp2 ratio yields various types of DLC that enhance hardness, reduce friction, and improve the corrosion resistance of the steel component.

The demand for DLC coating on steel components for endothermic and hybrid engines (pins, valves, camshafts, gears) is constantly growing; DLC improves engine performance and reduces emissions into the atmosphere.

In this presentation, the DLC deposited using the hybrid PVD-PaCVD (Physical Vapor Deposition-Plasma-assisted Chemical Vapor Deposition) technology will be examined. The modification of the layers, their thicknesses, compositions, and the containment of surface defects enhance the layer's hardness, reduce friction, and increase its resistance to corrosion. These characteristics can therefore be measured using laboratory instruments such as a nanoindenter, a contact tribometer, and a salt spray chamber. The next step is the bench test to assess results closer to real conditions. After laboratory analysis and bench tests, the applications are presented in 3 case histories: the increase in abrasion resistance in injection pins, the reduction in the friction coefficient on rocker arms, and the improvement in corrosion resistance in bipolar plates.

Sustainable bioplastics as durable cast film substrates for printed electronics, digital printing, and biosensor applications

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The increasing integration of digital printing technologies in printed electronics and biosensor fabrication has intensified the demand for sustainable polymer substrates that combine environmental compatibility with high mechanical durability, dimensional stability, and printability. Poly(lactic acid) (PLA), as a renewable, compostable, and non-toxic biopolymer, represents an attractive alternative to conventional fossil-based substrates commonly used in printed electronic systems. However, the limited resistance to thermo-mechanical stresses of PLA significantly restricts its applicability in digitally printed electronics and disposable biosensor platforms, where repeated handling, deformation, and processing stability are critical.

In this study, neat PLA and PLA-based copolyester cast film sheets was developed and subsequently biaxially stretched to induce molecular orientation via strain-induced crystallization. This approach was employed to enhance the mechanical toughness, dimensional stability, and durability of the films under conditions relevant to digital printing and biosensor integration. The results demonstrated that biaxial orientation improved the durability of PLA-based cast films, enabling their use as sustainable substrates for digitally printed conductive patterns, electronic components, and biosensing platforms. Thus, this work provides a viable pathway toward environmentally friendly substrates suitable for next-generation printed electronics and disposable biosensors, specifically for cost-effective glucose biosensors.

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TiO2 Nanotubes produced by two step anodization on hydrogen detection and electrical characterization

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Hydrogen energy is one of the important candidates in the search for an alternative energy source to fossil fuels due to their environmental hazards. The fact that hydrogen, which is colorless and odorless, has flammable and explosive properties at concentrations above 4% makes hydrogen safety an important issue [1]. Therefore, sensors that can accurately detect low concentrations of hydrogen at low temperatures are needed for hydrogen safety. This will ensure the safe use of hydrogen in the production, transportation, storage, and technological and industrial applications [2]. Titanium dioxide (TiO_2), has attracted attention in many technological applications due to its advantages in structural properties. TiO_2 nanotube production has been evaluated in gas sensor research due to the convenience it provides in the surface area [3].

One of the methods used for the production of TiO2 nanotubes is the anodization method [4]. Unlike previous studies, the dual anodization method was preferred in this study. In order to prepare the electrolyte containing 0.5% NH_4F, 47.25 mL of ethylene glycol, 2.50 mL of ultrapure water, and 0.25 g of NH_4F were added to the mixture as a result of the stock solution calculation for a 50 g sample. Platinum (Pt) and titanium (Ti), used as cathodes, were immersed in the electrolyte. The first anodization step was applied at 20 °C, 60 V, for 2 hours, and the formation of TiO2 nanotubes was observed. The second anodization step was applied at 20 °C, 40 V, for 1 hour. Thanks to the two-stage anodization protocol, nanotubes with morphological integrity, high regularity, and homogeneous wall thickness were produced. SEM images and XRD analysis were performed on the produced nannotubes.

Following the anodization process, electrical characterization and gas tests were performed on the completed Ti/TiO2 nanotubes/Pt device. The results showed that the nanotubes produced by dual anodization had better performance.

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Using Layer-by-Layer (LbL) deposition to prepare modified GCE with functionalized and/or pristine $Ti_3C_2T_x$ MXene-Graphene Oxide hybrids and their electrochemical evaluation

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Layer-by-layer (LbL) deposition is a versatile method to prepare thin film coatings with alternating layers of oppositely charged materials. The layers may be installed using different processes such as drop casting, dip coating, spin coating, spray coating, the choice of which have a significant impact in accurate reproducibility and the electrochemical properties of the resulting hybrid electrode.

The last few years a great intertest has being taken in the development and functionalization of 2D materials in electronic applications mainly due to their high conductivity. MXenes possess a unique combination of physicochemical characteristics that render them particularly attractive for sensing applications. Their electrical conductivity facilitates rapid electron transfer, which is essential for effective signal generation in electrochemical sensors. At the same time, their large surface area coupled with the presence of diverse surface terminations such as -OH, -O, -F, and -Cl provides abundant active sites and allows their functionalization with other materials such as Graphene Oxide (GO), leading to the formation of hybrids with improved and synergistic functional properties.

In this study, LbL deposition of $Ti_3C_2T_x$ MXenes and GO was employed for the modification of GCEs using two different assembly approaches, namely dip coating and drop casting. The influence of the deposition method on film formation, structure and interfacial properties of the MXene-GO hybrid electrodes were assessed using a combination of structural, surface, and electrochemical techniques, including Scanning Electron Microscopy (SEM), X-ray Diffraction (XRD), Water Contact Angle measurements (WCA), Cyclic Voltammetry (CV), Electrochemical Impedance Spectroscopy (EIS) and cycling stability tests. Results showed that the LbL-assembled hybrid coatings significantly enhanced the electrochemical performance of the modified electrodes compared to bare GCEs, while clear differences between dip-coated and drop-cast electrodes were observed in terms of charge transfer resistance, surface wettability, and electrochemical stability. Based on the above results, the developed hybrid electrodes could be used as electrochemical sensing platforms for glucose and lactate detection, exploiting the synergistic properties of MXenes and GO.

Engineering Functional Surfaces through Anodic Oxidation

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Anodic oxidation of titanium is an electrochemical surface treatment that enables controlled growth of a titanium dioxide (TiO_2) layer through anodic polarization in an electrolytic environment. The resulting oxide film enhances surface performance by improving corrosion resistance, biocompatibility, and optical response, thereby extending the applicability of titanium across aerospace, biomedical, architectural, and advanced design sectors.

A distinctive feature of anodically oxidized titanium is the formation of interference colors, originating from nanometric variations in oxide thickness and light–matter interaction. These effects allow precise and reproducible tuning of surface appearance without the use of pigments or coatings, offering a robust strategy for functional surface modification.

This work examines the relationship between anodizing parameters, oxide growth behavior, and resulting surface properties, with particular attention to the role of surface condition and processing routes. Experimental investigations were conducted by integrating laboratory-scale anodizing with engineering manufacturing techniques, including additive manufacturing and mechanical surface finishing, in order to evaluate their influence on oxide formation and color uniformity.

The results demonstrate that anodic oxidation can be effectively combined with advanced manufacturing processes to produce titanium surfaces with tailored functional and optical characteristics. This approach highlights the potential of electrochemical surface engineering as a versatile tool for controlling titanium surface properties.

Atomic modelling using density-functional theory and machine-learned interatomic potentials, and process optimization through active learning

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In a context of climate crisis, hydrogen technology emerges as a key factor, offering a clean fuel with a high energy density which can be produced through water electrolysis. However, the widespread usage of hydrogen as an energy vector is hindered by a significant bottleneck: most electrodes contain platinum group metals (PGMs) due to their high catalytic activity and stability. Such PGMs are scarce and costly and prevent the use of hydrogen and fuel cells on a larger scale. In this context, the NICKEFFECT project aims to develop novel (i) Ni-based coating materials to replace PGMs and ensure high efficiency in key applications such as fuel cells, and (ii) Ni-based ferromagnetic systems for random-access memory applications.

In this work, we present how active learning has been successfully applied to reach optimal catalytic performances of Ni-W dense coatings by tuning the deposition parameters [1]. Additionally, we show how density-functional theory and machine-learned force fields have been used to provide a better understanding of the magneto-ionic properties of Ni-Co oxide patterned microdisks [2].

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Machine learning–driven optimization of oxygen reduction reaction performance in electrodeposited Ni–W nanoparticles

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The development of platinum group metal free (PGM-free) electrocatalysts is essential to progress towards affordable oxygen reduction reaction (ORR). In this work, Ni-W nanoparticles (NPs) were electrodeposited on carbon cloth (CC) under both direct current and pulsed conditions from a gluconate-based electrolyte [1]. Machine learning (ML) was employed to identify the optimal deposition parameters for enhancing ORR performance in alkaline medium. The variables tuned during NP synthesis included temperature, overpotential, deposition time, and the rotation speed of the electrode, the latter controlled using a rotating disk electrode (RDE) to regulate mass transport.

For the electrochemical characterization, 200 cyclic voltammetries were performed in 0.1 M KOH on a three-electrode cell configuration with a RDE as the working electrode. The key parameters used to evaluate the catalytic activity and durability of the NPs were the half-wave potential and overpotential, both measured at the first and last cycles.

The morphology of the deposited NPs was examined by SEM to determine particle distribution across the CC substrate and particle size, which ranged from 40 nm to 600 nm depending on the deposition conditions. High-resolution (S)TEM imaging was conducted to elucidate the crystal structure and atomic distribution of Ni and W within the NPs. The analysis revealed that W preferentially accumulates towards the surface of the NPs, a feature that contributes to enhanced stability during ORR.

This work is funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Health and Digital Executive Agency (HaDEA). Neither the European Union nor the granting authority can be held responsible for them.

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Three-Dimensional Current Density Distribution Simulations and experimental determination of electrodeposited Porous Nickel-Tungsten on Fiber Cloth substrate

sciforum-164168

online as poster presentation (without DOI)

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Nickel-tungsten (Ni-W) alloys are promising alternatives to platinum group metals (PGMs) for electrocatalytic applications, offering a balance between cost-effectiveness and catalytic efficiency. While nickel is an effective catalyst for the hydrogen evolution reaction (HER), its performance can be significantly enhanced by alloying with tungsten. This synergistic effect improves catalytic efficiency, durability, and corrosion resistance, making Ni-W alloys suitable for renewable energy and energy storage applications. However, depositing uniform and stable coatings on porous substrates, such as carbon cloth, presents challenges due to non-uniform current distribution, which can lead to inconsistent deposition and degradation over time.

In this work, we present a novel approach to optimizing Ni-W electrodeposition on porous substrates by integrating experimental techniques with advanced computational modeling. Using the Multi-Ion Transport and Reaction Model (MITReM) combined with Butler–Volmer kinetics, we develop a 3D model to predict current density and layer thickness distributions. We also perform a detailed sensitivity analysis of key deposition parameters, including electrolyte conductivity, charge transfer coefficients, and current densities, to better understand their impact on Ni-W coating uniformity. Experimental results, including thickness distribution measurements, show strong agreement with the simulated data, validating the model's effectiveness.

This study not only provides valuable insights into the electroplating of Ni-W alloys on porous substrates but also offers a scalable, efficient approach to optimizing deposition parameters. The findings have significant implications for improving the plating of electrocatalytic materials and process efficiency, with potential applications in renewable energy and industrial-scale electrochemical systems.

Nanoscale droplet simulations: A computational framework to quantify wetting

sciforum-164480

online as poster presentation (without DOI)

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Fuel cells (FCs), including those based on proton-exchange membranes (PEMFCs), are a promising energy-conversion technology that is currently being used in electrified transport applications[1]. There is an ongoing effort to improve their performance, cost, and durability. However, the components of PEMFCs are made of different materials, and the study of their interactions requires the use of multiscale simulation methods.

In this work, we focus on the atomistic-level study of one component of the PEMFC: the microporous layer (MPL). One fundamental aspect of MPLs is water management (2). We aim to investigate this water management by determining wettability characteristics through the computation of the contact angle using molecular dynamics[3].

To streamline this process, we present a Python package designed to analyze simulation outputs and predict the contact angle of droplets surfaces. This computational approach allows for the precise quantification of wetting properties. Indeed, by exploiting such simulations, we can understand better how surface treatment at the nanoscale influences macroscopic efficiency. This integration of molecular modeling and data analysis provides a robust predictive framework for designing the next generation of high-performance surface coatings.

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Decision Support System for Safe & Sustainable Innovation in NICKEFFECT

sciforum-164598

online as poster presentation (without DOI)

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To integrate the Safe and Sustainable by Design (SSbD) framework into advanced material development, there is a critical need for robust tools and Decision Support Systems (DSSs). These enable early-stage evaluation of safety, sustainability, and performance trade-offs.

Within the NICKEFFECT project, we have developed a prototype of such a tool, consisting of a Material and Process Information Management System (M&P IMS) coupled with a series of modular analysis components. These include machine learning algorithms for performance optimization, early-stage safety assessment modules, and a simplified life-cycle analysis (LCA) engine to evaluate environmental impacts.

The M&P IMS employs a carefully designed schema linking materials, batches, samples, equipment, tests, and chemical substances—ensuring full traceability and enabling structured search, comparison, and reuse of data. On top of this knowledge base, the DSS offers modular applications that transform raw experimental data into actionable insights: comparing performance, conducting regulatory risk assessments, and estimating environmental impacts, all within a unified web-based interface. It caters to both experts and non-specialists, enabling SSbD decision-making early in the development pipeline and minimizing costly redesigns.

In the contribution we will show how the system can be utilized to support the replacement of Platinum group metals in ferromagnetic coating materials.

Multiscale and data-driven analysis of chemical vapor deposition processes

sciforum-180475

online (without DOI)

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Chemical vapor deposition (CVD) is a key manufacturing technique widely used in the semiconductor, energy, and advanced materials industries to produce thin films with controlled composition and microstructure. However, the underlying mechanisms governing CVD processes are inherently complex because they involve phenomena occurring across multiple spatial and temporal scales, including gas-phase reactions, transport processes, and surface chemistry. In this study, the interplay between these multiscale effects and the role of operating conditions in determining film growth behavior are systematically investigated. A multiscale computational modeling framework is developed to couple reactor-scale transport phenomena with surface reaction kinetics, enabling a more comprehensive understanding of deposition dynamics. In addition, data-driven analysis methods are employed to identify patterns and correlations between process parameters and resulting film properties. The computational results are validated using experimental measurements, providing insights into how temperature, pressure, and precursor concentrations influence deposition rates and film uniformity. This combined modeling and data-driven approach offers a pathway toward improved prediction, optimization, and control of CVD processes in advanced material fabrication.

Multiscale simulation of PVD coating on complex objects in motion: From gas phase modelling to atomic scale film growth

sciforum-164305

online as oral presentation (without DOI)

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Efficient thin film deposition by PVD can be challenging in numerous situations like complex-shaped objects or systems of multiples objects in competition due to shadowing. As an example, we can think about deposition of hard coating on cutting tools.

In this work, we are investigating thin films deposited by magnetron sputtering process on drill bits placed on a holder in motion. The aim is to show if and how the conformality of such coating can be obtained with such process.

The deposition process is modelled by combining Computational Fluid Dynamic (CFD), Monte-Carlo algorithm and ray-tracing (using the software Virtual Coater) to be able to predict the fluxes deposited on the meshed 3D objects. This modelling tool is coupled to an atomic scale kinetic Monte-Carlo model to simulate the time dependent growth of the film at different positions of the samples. A special attention is paid to the influence the kind of motion or the number of pieces in the chamber on the conformality of the coating.

This approach allows to reduce substantially the R&D time which is necessary to find optimal process parameters. Moreover, such modelling workflow can be extended to any study implying PVD deposition on large number of objects in motion, like in e.g. hard coating on ball bearing for medical applications, or coating of micron-scale particles in the domain of battery.

A Multiscale Modelling Framework for Adhesion, Etching and Ni Deposition in Cr(VI)-Free Metallization of Polymers

sciforum-163182

online as oral presentation (without DOI)

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Developing sustainable alternatives to Cr(VI)-based metallization requires a mechanistic under-standing of adhesion, surface activation, and metal deposition across different length and time scales. Within the FreeMe project, we have es-tablished a unified multiscale modelling frame-work that links atomistic reactivity, interfacial behaviour, and mesoscale metal deposition phe-nomena relevant to Cr(VI)- and Pd-free Plating on Plastics (PoP).

Adhesion between polymer substrates and epoxy resins was characterised through classical Molec-ular Dynamics simulations. The methodology was first applied to PLA–epoxy systems and sub-sequently extended to ABS with different epoxy formulations, enabling the prediction of interfa-cial energies, resin penetration and structural or-ganization in relation to adhesion performance.

The chemical etching stage was analysed through complementary quantum and reactive simula-tions. Density Functional Theory calculations re-solved complete oxidation pathways for the ABS monomers, identifying feasible mechanisms and activation barriers for piranha-based etching. Re-active Molecular Dynamics (ReaxFF) simula-tions reproduced the dynamic interaction be-tween oxidants and the polymer surface, reveal-ing composition- and energy-dependent diffu-sion regimes, penetration depths and the evolu-tion of functional groups. Kinetic Monte Carlo simulations were used to extrapolate the oxida-tion patterns to longer times, predicting the tem-poral increase in surface energy associated with activation.

Finally, the deposition of nickel on etched ABS was investigated using a coarse-grained model, which captures mesoscale interactions between Ni species and the polymer surface. The model predicts Ni coverage as a function of temperature and pressure and identifies the dominant bead-level interactions governing deposition

This framework provides a predictive, SSbD-aligned toolset to support the design and optimi-sation of sustainable metallization processes for polymer substrates.

Digital Innovation for PFAS-free Coating Development: The PROPLANET Replication Tool

sciforum-167346

online as oral presentation (without DOI)

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Modern industrial coating applications rely heavily on per- and polyfluoroalkyl substances (PFAS), which are valued for their exceptional functional properties. However, growing evidence of their environmental persistence and potential health risks has prompted regulatory action and an urgent need for safer alternatives. The PROPLANET project addresses this challenge by developing PFAS-free coating solutions using the Safe and Sustainable by Design (SSbD) framework, which embeds human health and environmental safety from the earliest stages of innovation.

Traditional coating development relies on costly trial-and-error experimentation. The PROPLANET Replication Tool transforms this approach by providing a comprehensive digital platform that enables researchers and industry to evaluate new formulations before physical testing. The software is a result of five key inputs: first-principles simulations that

examine coating performance at the molecular level; environmental fate models predicting where substances disperse and accumulate in ecosystems; lung exposure assessments evaluating inhalation risks; multi-objective optimization algorithms identifying optimal compound combinations balancing emissions and production requirements; and toxicological risk classification of the compound mixtures, based on the information obtained from the ECHA database.

By centralizing these diverse models into a single, user-friendly interface, the tool allows users to design coating formulations that meet specific performance requirements—such as hydrophobicity or oleophobicity—while ensuring environmental compliance and minimizing health hazards. This data-driven methodology significantly reduces research costs, laboratory waste, and development time, embodying a "First Time Right" philosophy.

Developed as an open-source platform, the PROPLANET Replication Tool democratizes access to advanced simulation capabilities, enabling stakeholders across industries to adopt sustainable practices. This digital innovation represents a critical step toward widespread replacement of PFAS with safer alternatives while maintaining the high-performance standards demanded by modern applications.

Integrating Simulation and Electrochemical Insights for Nickel-Based MMC Coatings

sciforum-164357

online as oral presentation (without DOI)

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The EU-funded MOZART project investigates nickel-based dispersion coatings incorporating nanoparticles as a viable alternative to hard chrome. This Mixed Metal Composite (MMC) approach has already demonstrated excellent mechanical properties, achieving hardness values up to 1000 HV.

Because nanoparticles do not undergo electrochemical discharge at the cathode, conventional electroplating models cannot predict their incorporation into the deposit. A major challenge lies in nanoparticle agglomeration, which can lead to precipitation and uneven distribution within the coating, particularly across surfaces with varying orientations. To address this, electrochemical characterization of plating bath chemistries is performed under different geometric conditions. These insights, combined with Computer-Aided Engineering (CAE) tools, enable prediction of particle content within the nickel matrix across complex component surfaces.

This contribution presents the integration of electroplating simulations with particle co-deposition modeling and highlights the design of plating tooling for multiple demonstrator parts. The proposed methodology establishes a framework for developing tailored tooling solutions, supporting the adoption of MMC coatings as a sustainable replacement for hard chrome.

Machine Learning for metallic coatings modeling & quality prediction

sciforum-164380

online as poster presentation (without DOI)

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Data-driven AI, based on Machine Learning (ML) methods, can be used for High Entropy Alloys (HEAs) coatings' modelling and quality prediction. Using experimental or historical data concerning HEAs coatings' processes & materials, ML can be useful in cases that physics-based models do not exist, are not adequate or are not efficient e.g. due to new composition of alloys, new coatings processes' parameters, multi-scale modeling, stochastic factors that influence quality, etc. Using ML methods, including Artificial Neural Networks (ANNs), Classification and Regression methods, ML models can be created to predict alloys' structure (e.g. crystal structure) & coatings properties (e.g. hardness) and for several alloy compositions and temperatures. This ML modeling approach is being applied within the Horizon Europe project M2DESCO, and several ML methods & training algorithms have already been used and tested within the project with satisfactory results, including the Feed-Forward Multilayer Perceptron (FF-MLP) ANN using the Backpropagation training algorithm, and ML Classifiers, like the LBFGS Maximum Entropy Multiclass Classifier and the Light Gradient Boosting Machine (LightGBM) Classifier. Especially the LightGBM multiclass classifier provided the best alloys' properties prediction results for 2 of the alloys used in the project, which were the Co-Cr-Fe-Mo-Ni and Al-Cr-Mo-Ti-W alloys, and for several compositions (molar fractions) of these alloys.

Mitigation of Wind Turbine Losses Using Simulation-Based Investigation of Micro-Engineered Antifouling and Anti-contamination Surface Technologies

sciforum-164440

online as oral presentation (without DOI)

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Biofouling and surface contamination on turbine blades can substantially increase aerodynamic drag, which reduces efficiency and accelerates corrosion-driven material degradation. To address these challenges, biomimetic coatings have been heavily experimentally researched as passive mitigation surface treatments. The use of superhydrophobic (SHB) and superhydrophilic (SHL) biomimetic coatings reduces the adhesion of fouling organisms and is considered to provide antifouling, anti-icing, anti-corrosion, and self-cleaning properties.

Although extensive state-of-the-art analyses of these surface textures have yielded volumes of data, this data is disconnected and lacks the coherency needed to identify, design and optimise an effective surface technology. This is due to the lack of informed selection data of texture morphologies and densities, which is due to the lack of related simulation studies. As a result, most experimental studies randomly select and test texture morphologies without understanding how specific structural features influence biological and mechanical surface degradation phenomena.

This paper presents a study on the interfacial influence of various biomimetic surface morphologies and densities on water droplet impacts. Three different morphologies with different interpillar distances were simulated to create either SHB or SHL surfaces on Ansys Fluent. Results indicated that morphologies influence the maximum pressure and maximum spreading diameter of the impacting droplet. Phase 2 of this study will provide preliminary data on morphology-design optimisation. Seven parameters were evaluated using one-factor-at-a-time sensitivity analysis. In this stage, coupled level-set and VOF method was used and the results showed in SHB textured surfaces the impact velocity and droplet diameter strongly influence the outcomes. For SHL surface designs, the ambient temperature had the largest effect on the outcomes and showed more nonlinear relationships. Due to the nonlinear effect, further factorial analyses will use a design of experiments (DOE) approach, such as the Box-Behnken method, to investigate the selective/collective synergistic/antagonistic influences of the selected parameters.

Multiobjective optimisation framework for the sustainable-by-design assessment of industrial coating production processes

sciforum-164309

online (without DOI)

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In this work, we present an optimisation-based decision support framework developed within the PROPLANET project, aimed at assisting potential users of the PROPLANET Replication Tool in the design and assessment of sustainable by design (SSBD) coatings production processes.

According to the information obtained with simple box for planet (SB4P) two multiobjective optimisation models have been formulated to simultaneously maximise coating production volume and minimise pollutant emissions generated along the production chain across different environmental media, including air, water, and soil. The model explicitly accounts for the final performance and quality properties of the coatings, ensuring that sustainability improvements are achieved without compromising functional requirements.

To approximate the Pareto front of the formulated problem, multiobjective metaheuristic optimisation techniques have been applied, specifically the Non-dominated Sorting Genetic Algorithm II (NSGA-II). The resulting set of solutions provides decision-makers with a structured overview of feasible compromises, enabling informed choices depending on production goals and environmental constraints.

The proposed approach demonstrates how multiobjective optimisation and simulation-based methods can effectively support decision-making in the development of sustainable industrial coatings, highlighting the potential of evolutionary optimisation tools to accelerate the transition towards environmentally responsible manufacturing processes.

POPEYE - Plating On Plastics Equation-based sYstems Engineering: Unit operations and properties prediction models for emerging plating on plastics technologies

sciforum-168308

online as poster presentation (without DOI)

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Plating on Plastics (PoP) is a continuously growing manufacturing technology for the production of several everyday (e.g. home appliances, automotive compartments) and advanced (e.g. aerospace) applications. The traditional process uses toxic Cr^{6+} and Pd critical raw material raising environmental, health, and supply concerns. This work presents a process systems engineering framework for the modeling, design and optimization of a novel SSbD PoP technology (EU-Funded FreeMe project) replacing Cr^{6+} and Pd with piranha solutions (H_2O_2–H_2SO_4), nickel-salts and NaBH4 for the pretreatment of plastic surfaces before metallization. State of the art and data-driven models were developed for the four proposed novel processing stages (i) etching with piranha, (ii) surface activation with nickel-salts, (iii) surface reduction with NaBH4, and (iv) metal plating.

A contact angle property prediction model was developed as a function of the etching conditions describing the piranha etching mechanism. The clever use of data and models further enables the correlation of contact angle with the hydroxyls surface concentration quantifying etching performance. Next, an activation efficiency model and a surface reduction kinetic model were developed as functions of process conditions. Last but not least, a regression method enhanced with data re-mapping was constructed as an extrapolable model for the prediction of the coating adhesion specification on the plastic substrate with respect to surface characteristics.

The models were constructed as an optimization Decision Support Tool considering economic, environmental, safety and SSbD objectives to assist PoP practitioners optimally tune their pilot/industrial lines for SSbD plating on plastics using the new technology. A BETA version of the DST was developed for stakeholders' experimentation enabling the user to define their production characteristics and requirements (adhesion, thickness). All process operating variables for PoP of 6 items of 150 cm2 (each) were optimized reaching adhesion (2.5 MPa) and thickness (25 µm) specifications at optimal SSbD criteria.

Simulation-Based Evaluation of Wear-Resistant Hardfacing Seams on Tillage Coulter Points

sciforum-165614

online as oral presentation (without DOI)

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Wear-resistant coatings and hardfacing technologies are widely applied to soil-engaging agricultural tools to extend service life; however, their influence on wear evolution and contact loading remains insufficiently quantified. This study presents a simulation-based evaluation of hardfacing seam configurations applied to cultivator coulter points, focusing on abrasive wear development and surface loading behaviour. Discrete Element Method (DEM) simulations were performed using ANSYS Rocky to model soil-tool interaction under representative field conditions. Several reinforcement seam arrangements located at the cutting edge were analysed and compared with an unreinforced reference geometry.

To address limitations related to multi-material wear modelling, a dedicated numerical approach was employed, enabling reliable simulation of reinforced geometries during progressive wear. The results indicate that optimized hardfacing seam placement significantly modifies soil flow and contact conditions on the coulter surface. When reinforcement seams were partially worn and actively protecting the cutting edge, volumetric wear of the coulter point was reduced by up to 40% compared to the unreinforced tool. At the end of the simulated wear process, the total wear reduction remained approximately 28%.

Additionally, specific seam configurations generated a soil-lifting effect, reducing the pressure acting on the coulter point working surface by up to 12%, thereby slowing wear progression rather than directly reducing overall draft force. Simulation results showed good qualitative agreement with field measurements, with deviations within approximately 5%, confirming the reliability of the modelling approach. The study demonstrates that DEM-based simulation is an effective tool for optimising hardfacing seam configurations and improving the performance of wear-resistant coatings in agricultural applications.

Strategies for Improved Metal Coating Penetration in Porous Structures Using MITRe Modeling

sciforum-164355

online as oral presentation (without DOI)

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The application of electrodeposition processes for providing porous structures such as foams, fiber cloths or packed fiber beds with a metallic coating remains a challenging process, since the throwing power of these processes into the porous structure is in general very poor. In this presentation, it will be demonstrated by simulations for an acid copper deposition process that the deposit thickness decreases very rapidly when progressing further into a fiber cloth structure. The simulated results were obtained from a FEM based Multi-Ion Transport and Reaction (MITRe) model with transport and kinetic electrode reaction parameters that are relevant to an acid copper deposition process. The same MITRe model is used for investigating different mitigation strategies aiming at an enhanced throwing power in the fiber cloth structure. It is demonstrated that a carefully defined forced electrolyte flow system and the application of pulse current programs can largely enhance the throwing power.

Theoretical and ML-based method for thickness estimation of coatings on rough substrates using nondestructive SEM imaging

sciforum-175869

online as poster presentation (without DOI)

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Quantifying the thickness of thin coatings on rough substrates is essential for process control but usually relies on destructive cross sections or techniques that assume laterally uniform films. We present a non destructive framework that estimates deposited thickness from paired top down SEM images acquired before and after coating, targeting films that are thin relative to the lateral spacing of surface features. In the analytic route, we treat coating as an effective geometric dilation of substrate features. For binarized images, the increase in bright area, normalized by the average of the pre and post deposition perimeters, yields a first thickness estimate. An overlap correction is introduced to account for feature coalescence after deposition, which would otherwise bias the estimate upward when asperities merge. Tests on synthetic shapes and numerically generated rough landscapes show that the corrected estimator reduces both bias and variance, with robustness improving for surfaces with larger correlation lengths. Application to experimental SEM pairs from coated rough substrates gives thickness values consistent with independent indications. Two machine learning modules complement the analytic approach. A supervised regressor that ingests before and after images together with difference channels predicts an effective dilation length calibrated to nanometers and reduces sensitivity to segmentation choices. A U-Net model performs an internal consistency check by reconstructing a plausible pre deposition image from a post deposition image and a scalar thickness, supporting the thickness as dilation interpretation for the explored coating and roughness ranges.

REACH-Compliant Nickel-Based Metal Matrix Composites for Tribological Applications: A Sustainable Alternative to Hard Chromium from the MOZART Project

sciforum-172129

online as poster presentation (without DOI)

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The MOZART project brings together partners from both industry and academia to address the challenging task of replacing hard chromium (HC) plating with a REACH-compliant alternative capable of delivering comparable performance.[1] Chromium trioxide, the basis of HC coatings, is classified as carcinogenic, mutagenic, and sensitizing to skin and respiratory pathways, and must therefore be phased out under REACH. Nickel plating, already widely used in industry, represents a less harmful option, and literature demonstrates that nickel-based metal matrix composites (MMCs) reinforced with hard ceramic particles can achieve hardness values close to those of HC coatings (≈1200 HV). Nevertheless, conventional nickel baths still present toxicity concerns, particularly due to the use of boric acid as a buffering agent, which is considered toxic to reproduction.[2]

In this context, Politecnico di Milano, as a partner of the MOZART project, developed nickel-based nanocomposite coatings reinforced with hard ceramic nanoparticles using electrodeposition from a succinic acid bath. Succinic acid, a di-carboxylic acid with dissociation constants of 4.2 and 5.6, provides effective buffering around the operating pH of 4.6, eliminating the need for boric acid. The most promising results were obtained by co-depositing boron carbide nanoparticles within the nickel matrix. Optimal conditions were identified as 10 g/L of dry nanoparticles dispersed in the electrolyte using sonication and a current density of 30 mA/cm², with a total charge exchanged of 36 C.[3] From a tribological perspective, the coating exhibited a coefficient of friction (CoF) of 0.12 under dry sliding conditions, which remained stable until progressive reduction of the surface roughness occurred as a result of continuous sliding. These findings highlight succinic acid-based electrolytes as a viable, REACH-compliant pathway toward sustainable, high-performance tribological MMC.

[1] European Union, Mozart project [Online]. Accessed on 10th December 2025. Available at https://www.mozart-project.eu/# n.d.

[2] European Chemicals Agency, Understanding REACH [Online]. Accessed on 10th December 2025. Available at https://echa.europa.eu/regulations/reach/understanding-reach n.d.

[3] Zoia F, Bernasconi R, Afzali P, Lopez LM, Magagnin L. Electrodeposition of REACH compliant boron carbide reinforced nickel composites for wear protection. Surf Coat Technol 2026;520:132996. https://doi.org/10.1016/j.surfcoat.2025.132996.

Assessing Market Readiness and Business Models for PFAS-Free SSbD Coating Solutions

sciforum-168013

online as poster presentation (without DOI)

IOANNA KATSAVOU, Apostolos Parlamas, Nikolaos Tsiantis, George Pagkalos

[1] EXELISIS IKE

The PROPLANET project is a Horizon Europe–funded research and innovation action aiming to develop next-generation, PFAS-free coatings following the Safe-and-Sustainable-by-Design (SSbD) framework. PFAS (per- and polyfluoroalkyl substances) are a large group of synthetic chemicals widely used for their water-, grease- and stain-repellent properties, but they are persistent in the environment, accumulate in living organisms, and are increasingly linked to adverse health and ecological impacts.

PROPLANET project targets three key industrial value chains where high-performance coatings are essential and environmental impact is critical: (i) textiles, (ii) glass, and (iii) food-packaging machinery. Across these sectors, PROPLANET seeks to replace existing coatings that contain PFAS with innovative bio-based and hybrid coating solutions that maintain functional performance while significantly reducing environmental and health risks.

This work emphasises market readiness and exploitation potential of the developed solutions. A comprehensive market assessment was conducted for each value chain, identifying target applications, and end-user needs. Moreover, a structured patent landscape analysis was performed, mapping existing intellectual property, as well as innovation gaps relevant to PFAS-free coating technologies.

To support future commercialisation, tailored business models were developed for key exploitable results, using tools such as the Business Model Canvas. In addition, circularity aspects were assessed to ensure that the proposed coatings contribute to resource efficiency, reduced chemical footprints, and alignment with EU circular economy objectives.

Cr^{6+} and Pd Free Metallization of Plastics

sciforum-166029

online (without DOI)

Michalis Kartsinis[1], Alexios Grigoropoulos[1], Alexandros Zoikis-Karathanasis[2]

[1] Creative Nano PC, 43 Tatoiou Street, Metamorfosi, 14451 Athens, Greece

[2] Creative Nano PC

Plating on plastics (PoP) is widely used in the automotive, electronics, and home appliance industries to enhance mechanical strength, corrosion resistance, and aesthetic quality. Polymer surfaces must be pretreated to enable the electroless deposition of a **Ni-P conductive layer**, which in turn provides the necessary foundation for the subsequent electroplating steps. Conventional industrial processes typically employ **hexavalent chromium (Cr^{6+}) based etching solutions**, which are highly toxic and carcinogenic, along with activators containing **palladium (Pd)**, which is considered as **critical raw material** and presents significant economic challenges due to its high cost.

This study provides a sustainable and cost-effective alternative to PoP by **replacing chromic acid etching with environmentally benign acidic solutions** and **substituting Pd with Ni for activating** ABS, PC-ABS, and Nylon-12 surfaces. Surface chemical modifications, morphology and adhesion were evaluated using FT-IR, water contact angle measurements, SEM-EDX and pull-off adhesion tests. The results demonstrated that uniform, thin and well-adhered Ni-P conductive layers can be deposited on all three polymer substrates. Moreover, the technology was successfully applied to real components with complex geometries that are used in aerospace, home appliances and automotive applications, highlighting its practical viability and reinforcing its contribution to greener surface-coating processes.

From Strain to Solution: The Integrated Natural Product Discovery Platform at Fraunhofer IME

sciforum-174320

online as poster presentation (without DOI)

Maria A. Patras, Marius Spohn, Michael Marner, Sanja Mihajlovic, Celine Zumkeller, Till F. Schäberle

[1] Fraunhofer Institute for Molecular Biology and Applied Ecology, Branch for Bioresources, Gießen, Germany

Fraunhofer IME's Natural Product Department specializes in bioactive molecule discovery, leveraging a premier collection of over 130,000 microbial strains. Utilizing a platform inherited from decades of industrial research, the department manages the full workflow from strain to purified product. This integrated pipeline translates innovation into marketable solutions across diverse sectors, including healthcare, nutrition, and specialized applications like sustainable antifouling.

Fraunhofer IME provides a highly adaptable research framework. Partners can choose a single project entry point or combine all three into a comprehensive discovery program:

Biobank Screening: Utilizing our microbial library of over 130,000+ microbes to identify novel bioactive scaffolds.Advanced Cultivation: Applying cutting-edge technologies (e.g., droplet-microfluidics and biomimetic environments) to isolate underexplored species from complex holobionts, such as coral reef and sponge microbiomes.Direct Analytics: Deploying our versatile analytical pipeline to investigate external biological matrices—learning directly from nature how organisms like marine sponges prevent fouling through chemical defense.

This approach provides access to a vast chemical space significantly superior in diversity and complexity to standard synthetic libraries. Crucially, these natural sources are inherently ecologically friendly and sustainable—a characteristic highly prioritized for next-generation antifouling agents. Furthermore, our pipeline is optimized for minimal sample requirements, ensuring efficient characterization even with limited material. Backed by comprehensive natural product databases and state-of-the-art metabologenomic tools, Fraunhofer IME provides a goal-oriented platform to turn innovation into sustainable, marketable products tailored for global challenges.

General Information

Coatings 2026: Safe and Sustainable by Design Surface Treatment and Coatings will be held at the Zeus - Wyndham Grand Athens, 20 – 22 April 2026.

Conference Venue
Zeus - Wyndham Grand Athens
Megalou Alexandrou 2, 104 37 Athens

Registration Desk
The desk for registration, information, and distribution of items will be open from 12:30 on 20 April 2026.

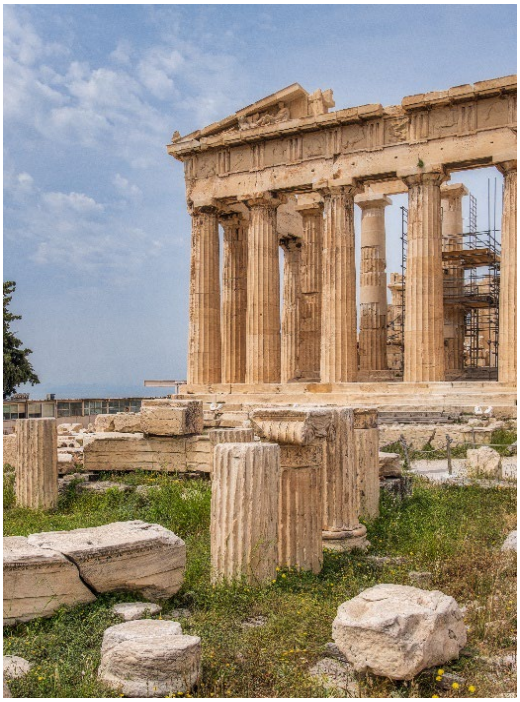
Certificate of Attendance
Participants of the event will be able to download an electronic Certificate of Attendance by accessing their dashboards on Sciforum.net once the event is concluded. The certificates will be found under the “My Certificates" category.

Disclaimer
Delegates will receive a name badge at the Information Desk, upon registration. The badge must be worn prominently in order to gain access to the congress area during the event. Admission will be refused to anyone not in possession of an appropriate badge.

Insurance
The organizers do not accept liability for personal accidents, loss, or damage to private property incurred because of participation in Coatings 2026. Delegates are advised to arrange appropriate insurance to cover travel, cancellation, and medical costs, and theft or damage of belongings.

Athens

Athens is the historic and vibrant capital of Greece, where ancient wonders meet modern delights. Steeped in rich history and mythology, Athens is a city that beckons visitors with its timeless allure.



Explore iconic landmarks such as the majestic Acropolis, where the Parthenon stands proudly, offering breathtaking views of the city. Immerse yourself in the city's ancient past at the National Archaeological Museum, housing a vast collection of artifacts from Greece's ancient civilizations. Stroll through the charming Plaka neighborhood, lined with picturesque streets, traditional tavernas, and quaint shops. Experience the lively atmosphere of Monastiraki Square, bustling with vibrant markets and enticing street food.

For art enthusiasts, the Benaki Museum and the Museum of Cycladic Art showcase magnificent Greek art spanning centuries. Athens also boasts a vibrant contemporary art scene, with numerous galleries and exhibitions.

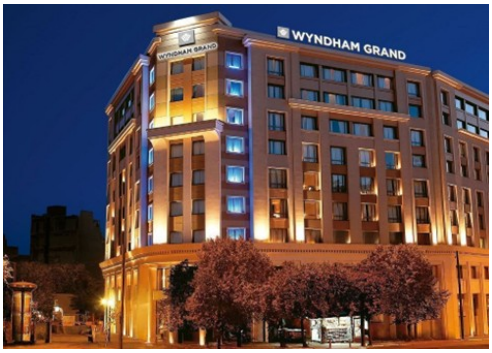
Indulge in Greek cuisine at the city's renowned restaurants, savoring traditional dishes like moussaka and souvlaki, accompanied by locally produced wines and spirits.

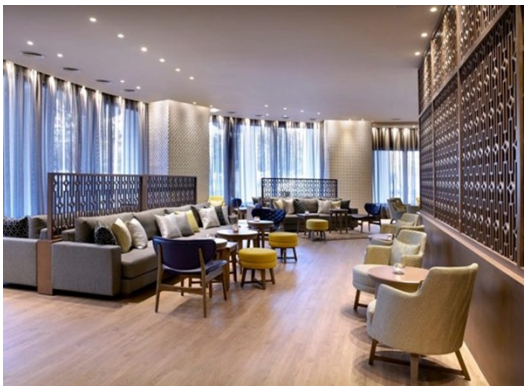
Athens' warm Mediterranean climate offers the perfect backdrop for wandering through the city, from the ancient Agora to the beautifully landscaped National Gardens. As you explore this captivating city, you'll find that Athens seamlessly blends its glorious past with its dynamic present.

Zeus - Wyndham Grand Athens

We are excited to host the Coatings 2026 conference at the Wyndham Grand Athens, a welcoming and stylish venue situated in the heart of the city. Just a few steps away from some of Athens' most iconic sights, it offers a warm, welcoming atmosphere with everything you need under one roof. From comfortable meeting spaces to beautiful views of the Acropolis, it is the perfect place to connect, share ideas, and be inspired. We can't wait to welcome you there!

Address: Megalou Alexandrou 2, 104 37 Athens





Access:

1. 3-minute walk from 'Metaxourgeio' Metro Station (M2/Red Line);
2. 16-minute walk from “Thiseio” Train Station (M1/Green Line); or 17-minute walk from “Monastiraki” Metro Station (M3/Blue Line & M1/Green Line);
3. 23-minute walk from 'Syntagma' Metro Station (M3/Blue Line & M2/Red Line);
4. The following bus lines have routes that pass near the venue: 057, 790, 031, 051, A15, and B15.

Conference Dinner

Tuesday, 21 April 2026, 20:00

Tickets must be purchased in advance.

We invite you to join us at the Conference Dinner at the Royal Olympic Hotel, a family-run five-star property in the center of Athens, which will make of your evening at the restaurant an experience to remember. The hotel lays just in front of the famous Temple of Zeus and National Garden, underneath the Acropolis, and only a 2-minute walk to the new Acropolis Museum.

The restaurant is located at the top of the Royal Olympic Hotel.

Address: Athanasiou Diakou 28, Athina 117 43, Grecia

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• JAMS - A complete manuscript submission system that incorporates all steps from initial submission to publication, including peer-review.

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If you would like more information about open access or any of our services listed above, be sure to talk to us at the MDPI booth. See you there!

Contact persons during the event

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Emergency Information

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Ambulance and health emergencies: 166

Fire brigade: 199

National Police: 100


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